Before the

Federal Communications Commission

Washington, D.C. 20554

In the Matter of	)	
Transition from TTY to Real-Time Text Technology	)	CG Docket No. 16-145
Petition For Rulemaking To Update The Commission's Rules For Access To Support The Transition From TTY To Real-Time Text Technology, And Petition For Waiver Of Rules Requiring Support Of TTY Technology	)	CG Docket No. 15-178

Comments of the Rehabilitation Engineering Research Center on Technology for the Deaf and Hard of Hearing, the Rehabilitation Engineering Research Center on Universal ! Interface and IT Access, and Omnitor !

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1. Introduction

The RERC on Technology for the Deaf and Hard of Hearing (DHH-RERC) is a project led by the Technology Access Program at Gallaudet University. The RERC on Universal Interface and IT Access (UIITA-RERC) is a project led by Trace Center at the University of Wisconsin-Madison. The RERCs are funded by the U.S. Department of Health and Human Services, Administration for Community Living, National Institute on Disability, Independent Living, and Rehabilitation Research, to carry out a program of research and development focused on technological solutions for universal access to systems and products for people with disabilities. Omnitor is a company in Sweden that focuses on developing accessible telecommunications solutions. The principal investigators of the DHH-RERC and UIITA-RERC have previously collaborated with Omnitor on the RERC on Telecommunications Access.

The RERCs and Omnitor (henceforth referenced to as the RERCs and Omnitor) would like to respectfully offer its comments on the FCC Order and Notice of Proposed Rulemaking on Transition from TTYs to Real-Time Text Technology. These comments contain a technical analysis of the NPRM on a paragraph by paragraph basis. Paragraphs are quoted in *italics with single spacing in a smaller font* where indicated, and our comments are in regular font face with double spacing.

2. Paragraph-By-Paragraph Comments

IV. Proposals for RTT Implementation

15. *We propose to amend the Commission's rules to replace our rules governing the obligations of wireless providers and manufacturers to support TTY technology with rules defining the obligations of these entities to support RTT over IP-based wireless voice services. Based on the record summarized above, we tentatively conclude that the technical and functional limitations of TTYs make this technology unsuitable as a long-term means to provide full and effective access to IP-based wireless telephone networks, and that there is a need to provide individuals who rely on text communication with a superior accessibility solution for the IP environment. We further tentatively conclude that RTT can best achieve this goal because it can be well supported in the wireless IP environment, will facilitate emergency communications to 911 services, allows for more natural and simultaneous interactions on telephone calls, will largely eliminate the need to purchase specialized or assistive devices that connect to mainstream technology, and may reduce reliance on telecommunications relay services.*

We agree with these conclusions and emphasize the importance of RTT being a natural part of every mainstream phone so that people who need to use real-time text (to make themselves understood to others, or to understand others) are able to call anyone else, rather than only people with special phones, special software, or who have had to configure special settings on their phone. Only if every mainstream phone supports RTT calls out of the box can the full potential of the TTY to RTT transition be achieved.

A. RTT Support by Wireless Providers and Manufacturers

16. *To achieve an effective and timely transition to RTT, we propose to require RTT support at a specified time in the future, but, as discussed further below, also seek comment on the extent to which there should be an interim period preceding such deadline, during which covered entities would be allowed to provide either RTT or TTY support on IP-based wireless services. We believe that establishing an RTT requirement is necessary to ensure that people with disabilities continue to have effective access to wireless communications services as these services make the transition to an all-IP environment, and we seek comment on this approach.*

    To this end, we propose the following revisions to the Commission's rules:

    Amend section 20.18(c) to require wireless IP-based voice service providers to be capable of transmitting 911 calls from individuals who are deaf, hard of hearing, deaf-blind, or speech disabled through RTT technology, in lieu of transmitting 911 calls from TTYs over IP networks;

    Amend Part 64 to require wireless interconnected VoIP service providers to support TRS access through RTT technology, including 711 abbreviated dialing access, in lieu of supporting TRS access via TTY technology;

Amend Parts 6 and 7 to require providers of wireless interconnected VoIP services subject to these rules to provide and support RTT, if readily achievable, in lieu of providing connectability and compatibility with TTYs; and

Amend Part 14 to require providers of wireless VoIP services subject to these rules to provide and support RTT, unless this requirement is not achievable, in lieu of providing connectability and compatibility with TTYs.

Yes, allowing a smooth transition to RTT support between now and the deadline is a good approach both for implementation planning for the service providers and for access by the users. However, there are **two important errors** in the two last bullet points in the bulleted list above. They state that RTT support shall be provided in lieu of TTY connectability and compatibility. TTY **connectability** is the function for local connection of a TTY to a device and it is correct that that requirement can be dropped. But the **compatibility** is the capability to have communication with remote TTYs, and that functionality must not be dropped until the time when TTY is not supported at all anymore (that is, when there is analog phone service anymore – since only TTYs will work on analog phones). The compatibility functionality needs to be provided by the telephone service providers through infrastructure for conversion between RTT and TTY.

In order to correct the errors, we propose the following modification to the amendment to parts 6 and 7:

"Amend Parts 6 and 7 to require providers of wireless interconnected VoIP services subject to these rules to provide and support RTT, if readily achievable**, in lieu of local compatibility (with the IP phone) but remote compatibility (with a TTY connected to an analog phone, or if you allow TTYs on IP phones during the transition, with TTY on another IP phone)** must be maintained; and"

Likewise, we propose the following modification to the amendment to part 14:

"Amend Part 14 to require providers of wireless VoIP services subject to these rules to provide and support RTT, unless this requirement is not achievable, in lieu of **local compatibility (with the IP phone), but remote compatibility (with a TTY connected to an analog phone, or if you allow TTYs on IP phones during the transition, with TTY on another IP phone) must be maintained**."

> *17. We believe that the availability of RTT-capable end user devices for users is essential in order to facilitate the use of RTT for emergency purposes, fully integrate RTT capability into the IP environment, and ensure that RTT users have the same range of device choices offered to the general public for voice communications. To this end, we further propose to amend the Commission's rules in the following manner to address the ability of wireless devices used by consumers to support RTT.*

There is another important justification for the availability of RTT, and we suggest amending the above wording to read: "the availability of RTT-capable end user devices for users is essential in order to facilitate the use of RTT for emergency purposes, fully integrate RTT capability into the IP environment, and ensure that RTT users have the same range of device choices offered to the general public for voice communications, **and to ensure that people who need to use RTT are able to call and converse with any other person using any phone, just as voice callers can.**"

> *18. Wireless service providers. For providers of IP-based voice services, we propose to:*
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> *Amend section 20.18(c), which requires the transmission of 911 calls from TTYs, and Parts 6, 7, and 14 to require that, to the extent a wireless provider issues design specifications, purchases for resale to users, or otherwise authorizes new handsets or other text-capable end user devices for use with its IP-based voice services, the provider shall ensure that such devices have the ability to send, receive and display RTT.*
>
> *If it is not readily achievable (under Parts 6 and 7) or achievable (under Part 14) to incorporate RTT capability within such wireless devices, the wireless provider shall ensure that such devices are compatible with RTT-equipped stand-alone devices or software applications, "if readily achievable" for equipment subject to Parts 6 and 7 of the rules, and "unless not achievable" for equipment subject to Part 14 of the rules.*

We suggest amending the above to read as follows: "Amend section 20.18(c), which requires the transmission of 911 calls from TTYs, and Parts 6, 7, and 14 to require that, to

the extent a wireless provider issues design specifications, purchases for resale to users, or otherwise authorizes new handsets or other text-capable end user devices for use with its IP-based voice services, the provider shall ensure that such devices have the ability to send, receive and display RTT, **and display RTT as part of the standard call and answer functionality of the voice service on the phone."**

19. *Manufacturers. For manufacturers of wireless handsets or other wireless text-capable end user devices used with IP-based voice services, we propose to amend Parts 6, 7, and 14 to require such manufacturers to:*

    Ensure that their devices have the ability to send, receive, and display RTT, if readily achievable for equipment subject to Parts 6 and 7 of the rules, and unless not achievable for equipment subject to Part 14.

    If it is not readily achievable (under Parts 6 and 7) or achievable (under Part 14) to incorporate RTT capability within such devices, ensure that such devices are compatible with RTT-equipped stand-alone devices or software applications, if readily achievable for equipment subject to Parts 6 and 7 of the rules, and unless not achievable for equipment subject to Part 14 of the rules.

We suggest amending the above to read as follows: "Ensure that their devices have the ability to send, receive, and display RTT **as a part of the default voice calling and receiving services on their devices,** if readily achievable for equipment subject to Parts 6 and 7 of the rules, and unless not achievable for equipment subject to Part 14."

20. *Our proposal to create an affirmative requirement for RTT support is consistent with past Commission actions and Congressional mandates to ensure that, as communications networks evolve to incorporate new technologies, accessibility safeguards be amended to ensure that people with disabilities continue to have effective access to communications. The purpose of section 716, added to the Act by the CVAA, is to ensure that "advanced communications services" that incorporate new technologies are accessible to individuals with disabilities. As explained by the Senate committee report on the CVAA, the CVAA's purpose is "to update the communications laws" to ensure accessibility, because, since the previous update in 1996 (when section 255 was added), "[i]nternet-based and digital technologies are now pervasive . . . [and] the extraordinary benefits of these technological advances are sometimes not accessible to individuals with disabilities." Thus, for example, section 716(d) expressly prohibits ACS providers from "install[ing] network features, functions or capabilities that impede accessibility or usability." By requiring wireless providers and manufacturers, as they deploy IP-based voice services, equipment, and networks, to implement RTT as a state-of-the-art accessibility technology, we will ensure not only that such networks do not impede accessibility, but that "the extraordinary benefits of technological advances" are accessible to individuals with disabilities as Congress intended.*
21. *Our proposals are also intended to avoid repetition of past failures to build in accessibility at the outset of technological changes, which led to long delays in providing access to new*

communications technologies for people with disabilities. For example, in the mid-1990s, despite the public safety dangers of leaving people with disabilities behind as the wireless industry made its transition from analog to digital technology, repeated delays resulted in the lack of access to digital wireless services by TTY users for over six years, well past the rise in popularity of digital technology with the general public. Similarly, it was not until 2005 that digital handsets began integrating hearing aid compatibility, again despite the introduction of these handsets in the mid-1990s. Each of these delays imposed considerable hardships on people with disabilities, who remained without digital wireless access – and without emergency access via wireless networks – for lengthy periods of time after these technologies became available to everyone else. Additionally, industry efforts that were needed to eventually achieve such access – which took place very late in the design and development process of building of such phones – proved more costly and burdensome than would likely have been the case had accessibility been incorporated from the outset.

22. *The Commission has noted that "[c]ommunication networks are rapidly transitioning away from the historic provision of time-division multiplexed (TDM) services running on copper to new, all-Internet Protocol (IP) multimedia networks using copper, co-axial cable, wireless, and fiber as physical infrastructure." As these changes take place, we seek to ensure that our accessibility rules for IP-based voice networks achieve the early integration of accessibility features, so that people with disabilities can enjoy communications services as they emerge, along with the general population. We believe that amending our rules to require support of RTT at this time is likely to create greater certainty for companies that have expressed an interest in deploying RTT, and provide a supportive regulatory landscape in which to do so. More specifically, with the action taken today, we expect that covered entities will have the necessary incentives to invest and innovate to improve products employing RTT functionalities, promoting more effective access to 911 services and other communications for individuals with disabilities.*

23. *We seek comment on our tentative conclusions, proposals, and analysis, including the costs and technical feasibility of the proposed rule amendments, and on any proposed alternatives.*

    We note that in its text-to-911 proceeding, the Commission determined that significant benefits could be attained by enabling people with disabilities to use text to access emergency services by phone. In addition, the Commission previously has recognized that as our nation ages, the number of Americans who may need alternatives to voice telephone communications is likely to increase. We further believe that establishing a requirement to ensure that RTT is incorporated in wireless IP-based services and devices as these are designed and developed will reduce the overall costs of incorporating this access feature, while ensuring that people with disabilities are not left behind as we transition to this new technology.

    We seek comment on whether these assumptions are correct and generally on the benefits to be derived from incorporating RTT functionalities into wireless services and end user devices, including the benefits that may accrue for improving access to 911 services.

The proposed approach of changing the rules is feasible. The cost will be manageable if time is allowed for a harmonized introduction, where providers use a common detailed specification for RTT. Specifying the "safe harbor" interoperability standard is key here. Companies in the past have been ready to deploy but were not willing to take the leap and invest in RTT when no standard was specified.

Allowing introduction of RTT into new designs from the beginning is a feasible and cost-effective approach for the transition. It is also feasible and important to provide access by RTT to 9-1-1. Although the current text-to-9-1-1 service fills an important gap, the limitations of SMS make it very slow and cumbersome to use compared to a real-time text conversation during a 9-1-1 call. Providing RTT during 9-1-1 calls is likely to result in improved reliability, and faster turnaround times and communication between the caller and the PSAP. Unlike SMS, RFC4103 has built-in redundancy and the capability to detect when information was lost. Moreover, because RTT is transmitted and received virtually instantaneously as opposed to SMS, the telecommunicator will be able to see the caller typing and start composing responses while the caller still types.

Finally, it is important to remember again that the largest group that will benefit from RTT on emergency calls will not be people who are deaf, or who primarily communicate in text, but rather people who normally communicate via speech but not reliably – and who cannot understand spoken instructions from 9-1-1 due to their hearing loss and/or due to problems with background noise.

24. *Technology Research Centers contend that the implementation of RTT would not add any hardware costs to support RTT, if limited to products used for receiving and displaying RTT that already have a display large enough to display multiple lines of text (or software designed to run on a multi-line display) and a mechanism for generating text for other purposes. They and others point out that many Internet-enabled terminal devices, including smartphones, tablets, and VoIP desk phones, already have such text generation and display capabilities. Additionally, the Technology Research Centers claim that "these costs will be kept down if real-time text design is incorporated in the beginning of the design process" when they "should be merely a small fraction of the overall design costs, which can be amortized across all the products sold – and carried forward to future designs." We seek comment on the merits of these assumptions, and on how they would be affected by the outcome of the issues raised for comment in this section regarding the scope of an equipment capabilities requirement.*

We agree with these assumptions. If the FCC specifies that the rules for receiving and displaying RTT apply only to VoIP devices with multiline displays (and to services

that have such devices connected to them) , and if rules about sending RTT apply only to devices that provide the user with the ability to enter text (in any manner), then there are no additional hardware requirements for respectively receiving and sending RTT, and thus no additional hardware cost. If the hardware has the display and text input capabilities, all the rest is software. The scope of implementing the software is de minimis compared to the overall scope of the capabilities of modern IP-enabled phones (even non-smart phones).

The RFC4103/T.140 RTT codec is available as open-source. Moreover, open-source implementations are available as models for how to implement the user interface, and have already been tested in practice.

Users can use the built in keyboards and other text entry methods for convenience or can connect external keyboards for faster smoother text entry, just as any other user of the device can. Such keyboards are available generally as accessories and are purchased by users who desire using them. No requirement that manufacturers provide external keyboards should be implied. And no requirement that manufacturers add any ***hardware*** to their devices to support connection of external keyboards should be implied or included. However if the device does have the ability to connect external keyboards, they should be usable with the RTT functionality on the phone.

B. Timelines

25. *Larger wireless carriers. We next seek comment on when our rules requiring implementation of RTT should become effective. We propose that this be completed by Tier I wireless service providers, which offer nationwide service, no later than December 31, 2017. AT&T and Verizon have indicated they will be capable of meeting this deadline, and information provided by AT&T suggests that this will allow ample time for RTT deployment.*

This timeline seems feasible. The providers have had time since the fall of 2015 to prepare. International standards are in place, apps with similar functionality are available, TTY gateways have been demonstrated[1], and similar gateways are in production in other countries.

> 26. *We believe that this implementation date will encourage expeditious deployment of RTT, yet allow a reasonable period for service providers to comply with rules adopted pursuant to this Notice. It will also respond to Consumer Groups' concerns that a longer deadline would leave vulnerable populations without access to TTY or accessibility solutions during and beyond the waiver period. We seek comment regarding this proposed implementation date for these carriers, and specifically whether it will afford sufficient time for this category of providers to achieve compliance with the rules proposed in this Notice. Alternatively, we seek comment on whether it would be preferable to establish a specified interim period of time – prior to the deadline set for an RTT requirement – during which Tier I covered entities would be allowed to support RTT over their IP facilities if they are unable to support TTYs. We ask parties that believe such interim period is necessary to explain whether and how such period would be needed to afford additional flexibility during the transition to RTT technology. We further ask commenters who disagree with our proposed deadline of December 31, 2017 for Tier I carriers to explain why additional time would be needed to achieve deployment of RTT.*

Yes, the only feasible solution is to let the carriers start providing RTT solutions instead of TTY connectability as soon as the regulations are in place and the requirements defined. A major reason for the move to RTT lies in the problems with providing good TTY connectability and reliable transport of TTY signals in an IP environment. Therefore, allowing a move to RTT without focusing backward on TTYs will enable the carriers to concentrate their efforts and investments on incorporating RTT into the design of the new services, rather than continuing to the increasingly difficult task of making TTYs work in their IP networks and devices.

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[1] Åström, L., Chourasia, A., Friberg, C., Hellström, G., Nordstrom, M., Tucker, P., Ulfsparre, C., Vanderheiden, G., Vogler, C., Williams, N. (2015). Real-Time Text Interoperability: Status and Field Trial. Online: http://tap.gallaudet.edu/IPTransition/TTYTrial/ (Last accessed: 7/11/2016)

We understand but are concerned, however, with any requests to stop TTY support now in exchange for RTT support later. We support this 'gap' in coverage only with an RTT roll-out date of December 31, 2017. But if this date is pushed out, it leaves people who need text communication in a lurch for too long a period.

27. *Smaller wireless carriers. We propose that smaller wireless carriers, to be defined as those that do not fall into Tier I, be given an additional period of time to achieve compliance with the proposed RTT support requirements beyond the deployment date proposed for the larger, Tier I carriers. We believe that allowing additional time for these carriers to achieve compliance would be appropriate, given that they generally serve smaller subscriber populations and may have fewer device options. We seek comment on what would be an appropriate extension of time, as well as whether we should distinguish between Tier II and Tier III carriers in determining appropriate benchmarks for these providers. Alternatively, we seek comment on whether it would be more appropriate to tie the obligations of these carriers to the timing of their transition to IP-based wireless technologies, such as IMS/VoLTE or 4G services. Finally, to what extent would it be appropriate to establish an interim transitional period, akin to what is discussed above for Tier I carriers, during which such smaller carriers would be allowed, but not required, to support RTT in lieu of TTY technology?*

All current implementations of RTT live on the open Internet in pre-IMS and pre-VoLTE environments. However, it is not more complicated to establish good RTT functionality in IMS and VoLTE environments than on the open Internet, and the relevant standards for IMS/VoLTE include RFC4103 and T.140[2]. The level of preparedness from Tier II and Tier III carriers, however, may be lower than for the Tier I providers, so therefore an additional period of 6 months after the Tier I provider deadline seems reasonable. They should, however be allowed to introduce RTT support whenever the regulations have defined the requirements, based on the same reasoning as in the earlier comments on similar questions.

28. *End user devices. We propose that the timeline established for RTT support over IP-based wireless services apply as well to handsets and other text-capable end user devices for use with such services, and thus propose that any such handsets or devices sold after December 31, 2017, have RTT capability. We seek comment on this proposal. Making this requirement effective at the*

[2] 3GPP (2015). Global Text Telephony, Stage 2. TS 23.226.

same time that wireless services are required to become RTT-capable would ensure that sufficient handsets are available for people with disabilities to have access to text communications in real time after the existing orders waiving service provider requirements for TTY support expire. Will the proposed December 2017 deadline for the Tier I service providers allow sufficient time incorporate RTT capability in end user devices? Is it more appropriate for the deadline established for end user devices to apply to the date on which new devices are manufactured, rather than first made available to the general public?

We agree that the same deadline for services and end-user equipment availability to users of Tier I carriers is appropriate. Having them both (networks and devices) with the same timeline is important to deployment. Otherwise, we encounter the proverbial chicken-and-egg situation, where there is no incentive to roll out the service due to a lack of end user equipment, and there also is no incentive to provide end user equipment due to a lack of available services. And it is important for the RTT to be in every handset as standard, so that people who need RTT can call anyone directly and without having to use relay services.

29. *In addition to requiring the inclusion of RTT support on new terminal devices, consistent with section 255's requirements for telecommunications access and the CVAA's requirements for access to advanced communications services and equipment, should there be a requirement to add RTT capability to end user devices already in service at the compliance deadline, at "natural opportunities," previously defined by the Commission to occur upon "the redesign of a product model or service, new versions of software, upgrades to existing features or functionalities, significant rebundling or unbundling of product and service packages, or any other significant modification that may require redesign?" Further, to the extent that it is not achievable under section 716 or readily achievable under section 255 to make an end user device accessible through RTT, by what date should such device be made compatible with a stand-alone RTT device or app to the extent that these become available?*

30. *We also seek comment on the period of time, if any, that over-the-top applications or plug-ins for RTT should be permitted as an interim measure to achieve RTT on end user devices, and if permitted as over-the-top applications, whether manufacturers and service providers should be required to pre-install such applications on devices before they are sold to the public. The DAC recommends exploring under what circumstances requiring telecommunications and ACS support for RTT as an embedded or "native" function would be appropriate, as well as an appropriate transition period for manufacturers and providers of telecommunications and ACS to achieve this capability. The DAC further recommends that "downloadable applications that provide the RTT functionality should be permitted until the eventual phasing in of native RTT functionality." We note that AT&T has reported that it expects to launch an OTT application to provide RTT by December 2017, and hopes to offer mobile devices with an embedded RTT solution by 2018. TIA, however, states that an approach allowing RTT to either be built-in or "added later" would afford manufacturers the flexibility they need and offer "the most practical approach to enable consumers to have access to an effective solution."*

A built-in native, and by default activated, solution in all new devices is the only approach that provides real functional equivalence, whereby users can have calls in any combination of RTT and voice with anybody else. And that should be the requirement. There may be a need for a transition period time until the native approach can be deployed. During that time period, a downloadable application is the most feasible interim TTY replacement. This downloadable app should be able to function as a standard VoIP phone for those that have voice plans – and not be an OTT app that uses data rather than the person's voice plan. Such a downloadable application could also provide an upgrade possibility for older devices that will never obtain the native functionality of newer devices – but it should only be used where system updates cannot be used to add the RTT feature to the built-in phone service on the device. There must, however, be a date certain after release of the final rules, where all phones manufactured after this date must provide native RTT implementations.

> 31. *We propose that use of an over-the-top application as an interim solution, such as that which AT&T is achieving, will be sufficient to constitute compliance with the RTT requirement by December 31, 2017, and seek comment on this tentative conclusion. At the same time, we ask to what extent the Commission should be concerned that the advantages of RTT as a universal text solution will not be achieved until RTT is incorporated as a native function in end user devices, or at a minimum, pre-installed by the manufacturer or service provider as a "default" application. We seek comment on whether this concern should guide our final rules, and further seek comment on what functionalities of RTT, and what associated benefits of RTT, if any, would be unavailable if it is initially implemented as an over-the-top application rather than as native functionality. With this in mind, we ask commenters to provide specific parameters for and factual showings justifying any timelines they propose for transitioning to native RTT functionality in covered devices.*

As stated above, a built-in, and by default activated, solution in all new devices is the only approach that provides real functional equivalence, where users who need to use RTT can have calls (in any combination of RTT and voice) with anybody else – in the same way voice callers can call anyone else (and not just those with a special app). Having RTT as part of the native phone calling functionality is also a prerequisite for

RTT to become sufficiently known among deaf and hard-of-hearing users – and especially the elderly – and that they and their loved ones, friends, doctors, senior service agencies and others can call them and be reached by them with everyone using their regular phones.

If RTT were relegated to an over-the-top application, many people who are deaf or hard of hearing would not be sufficiently aware to install it, especially the elderly. In the same vein, most of the hearing people and services whom they would call or receive calls from also would remain unaware of the RTT functionality. Moreover, even if they were aware, it is probable that having to download and install an extra app would constitute a sufficiently high hurdle that many would not bother – especially after switching phones or providers. Thus users could install it but not be able to call anyone and everyone who did not.

In short, if RTT were provided via a downloadable app only, only a fraction of all users would have RTT capabilities, and the major promise of RTT – the ability for any person with or without a disability to call anyone else via RTT, instead of relay services – would be lost. In the voice calling world, anyone can call anyone else via voice, and functional equivalence for RTT demands the same high bar for RTT and RTT+voice calls.

V. Advantages of RTT

32. *IP-Based Technology. There is general agreement among AT&T and those commenting on its petition that RTT is an effective alternative to TTY technology for the IP environment. Commenters concur that RTT "is a native IP technology designed for today's packet-switched network environment," which "offers an expanded array of features to enable more robust user conversations, including real-time editing of text and full-duplex functionality (i.e., both parties can communicate simultaneously)." Consumer Groups support RTT because it transmits text instantaneously during a call for real-time interaction, and allows for "the intermixing of speech with text," so that people can supplement speech for difficult-to-hear words. The Technology Research Centers add that RTT also can be used to supplement voice communications by*

individuals who do not typically use RTT, but who may be in a situation where text is beneficial, such as a noisy environment. CTIA claims that RTT is more spectrally efficient than TTY, as it uses fewer network resources.

33. *AT&T, Verizon, and other carriers have made a commitment to deploy RTT as a successor technology to TTY. AT&T states that RTT "is designed to operate on IP-based networks, [and] will be superior to TTY in every way – transmission speed, latency, reliability, features, privacy, conversation form, and ease of use." In this regard, AT&T notes that RTT conversations permit the seamless integration of voice and text, allowing parties to communicate simultaneously using a full set of characters, including characters used in languages other than English. Verizon adds that parties generally agree that "RTT will ultimately promote a higher degree of accessibility, functionality, and reliability than cumbersome legacy TTY devices currently provide, facilitate the transition to end-to-end Next Generation 911 (NG911), and meet the needs of legacy TTY users during the transition." For all of these reasons, we tentatively conclude that deployment of RTT on IP networks will offer functionality greatly superior to that of TTY technology, and we seek comment on this tentative conclusion.*

We agree that RTT provides all of the functionality of TTY, and holds many advantages over TTY. For example, due to the fact that it runs on IP, RTT supports voice and text in parallel in both directions simultaneously, supports interruption, and supports more than the limited character set of Baudot, to name a few key advantages.

34. *Off-the-Shelf Devices. Commenters also state that RTT will allow consumers with disabilities to make calls using the built-in functionality of a wide selection of off-the-shelf devices, including smartphones, tablets, computers and other Internet-enabled devices that have the ability to send, receive, and display text. These parties point out that this can eliminate the high costs and other challenges involved in finding, purchasing, and making effective use of assistive devices such as TTYs. In addition, the Technology Research Centers explain that in an emergency, individuals in distress would be able to use RTT on any text-capable phone available to them, and similarly would be able to communicate with anyone else without being concerned about whether the person they are calling has a specialized phone that can receive text. Enabling people with disabilities to use off-the-shelf devices, they add, also will eliminate difficulties associated with having to achieve compatibility between mainstream devices or networks and assistive devices that use non-mainstream text formats, allow consumers with disabilities to take advantage of device and service discounts, bundles and other arrangements available to the general public, and eliminate the need for friends, relatives, and colleagues of people who rely on text to communicate to purchase assistive devices or SCPE. For all of these reasons, we tentatively conclude that the ability to acquire off-the-shelf RTT-capable devices will be beneficial for text communication users, and we seek comment on this tentative conclusion.*

We agree with this conclusion. See also discussion under paragraph 31, which emphasizes the importance of native RTT functionality on every device.

35. *Substitution for Telecommunications Relay Services. Section 225 directs the Commission to ensure that TRS is available "in the most efficient manner." The record suggests that, because RTT will provide greater opportunities for direct, point-to-point text communication and can enable text to be intermixed with voice, it can reduce reliance on relay services and thereby provide consumers with greater privacy and independence, while reducing overall costs for telecommunications users. For example, one form of TRS, captioned telephone relay services*

> *(CTS), currently uses CAs to enable people who are hard of hearing to receive captions of conversation spoken by other parties to a telephone call. We expect that RTT users might not need these services if they were able to receive RTT over VoIP phones to supplement incoming voice conversations for difficult-to-understand words. Similarly, we predict that people with speech disabilities who can type will be able to use standard phones capable of generating RTT to communicate with other persons who also have VoIP phones with displays. However, we note that these results are likely to be achieved only to the extent that RTT capabilities in end user devices truly become ubiquitous – i.e., are enabled by default in all or most wireless (and eventually wireline) terminal equipment. To the extent that RTT is "supported" but not fully incorporated as a native or default function of devices – and is merely available for users to download or install – commenters suggest that the universal reach of text as a substitute for relay services will be less likely to be achieved, because many individuals who do not rely on text may not install this extra functionality. We seek comment on whether these assumptions are correct.*

We agree that this reasoning is correct. Widespread use of RTT is a prerequisite for a reduction in growth of TRS and CTS – if RTT users cannot call others directly, they will have no choice but to rely on relay services. In practice, a reduction will be best achieved when the general public adopts the use of RTT as a complement to voice calling in everyday calling. That also requires the service providers to include RTT in their services and devices as a desirable feature. RTT has its best opportunity to serve users in general if it is seen as an enhancement of telephony in general that just also happens to improve accessibility for people with disabilities.

In addition, RTT can hasten the successful use of speech to text technologies. While these technologies are currently not reliable enough to substitute for human captioners in the general case, mainstream RTT allows both parties to see the text output of speech recognition engines. In contrast to captioned telephony, where only one side receives the text, this in turn allows all parties to a conversation to catch speech recognition errors with respect to what they said, and correct such errors on their own. Especially when all parties talk and can see on their own phone when the speech recognition makes mistakes in recognizing what they said, they can respeak or type in the word or words – giving them accurate, private, and fast communication instantly. This is a potentially very

powerful new use case that can provide an option for some people to have private communication with loved ones using only speech recognition. And for those situations when speech recognition is not effective or appropriate, the captioned telephone service still is just a button press away.

> 36. *Improvement of Telecommunications Relay Services. In addition to substituting for TRS in some circumstances, we believe that RTT can be used to enhance the ability of TRS to provide functionally equivalent telephone service. For example, it would appear that for text-based forms of TRS, RTT can improve the speed and reliability of communications in an IP environment. The Technology Research Centers further note that individuals may be able to use RTT to supplement communications in sign language with text during VRS calls, reducing the time needed for CAs to convey detailed information, such as addresses and URLs. We seek comment on these assertions and whether there are other ways that RTT can improve the provision of TRS for its users.*

We agree that moving from both TTY and IP-Relay to RTT relay, as well as the capability to add RTT to VRS calls, are important steps to improve relay services. These steps have already been taken in Sweden, and the results are convincing. There, the TTY is of recognized low functionality and slow and inconvenient to use for text relay services. IP-Relays in USA are predominantly using text messaging technologies. In Sweden, RTT and text messaging has been available in parallel for text relay access. Most calls there are processed through RTT technologies. In the few cases where users call using text messaging technologies, CAs there commonly comment on the call: "I am sorry, this call is with a person using messaging, so it will be slow." That comment indicates that relay services with RTT access is experienced as more rapid than text message based relay services.

Also the VRS in Sweden offers access for Total Conversation users, that is audio, video and real-time text, and the real-time text part is seen as essential for conveying words requiring exact spelling, and names and addresses.

One important function of the US relay services that will require some extra planning to provide to wireless RTT users is the 10-digit number iTRS calling that IP-relay users and VRS users benefit from. The current technology for 10 digit calling requires specific numbers for users that are connected to specific services. For maximum accessibility and integration into the mainstream telecommunications ecosystem, there needs to be a way to invoke the appropriate relay service when a subscriber's wireless carrier-provided ten-digit number is called.. At present, the FCC has required the 10-digit iTRS number calling to be done in specific ways tied to specific relay services, and having the numbers in a common database. Applying the ten-digit number rules to wireless RTT calling may require some changes to the requirements on both the iTRS system and on the wireless RTT systems.

Providing interoperability between wireless RTT and VRS user terminals with RTT and TRS terminals with RTT provides good benefits to the users. They can use the same communication equipment for user-to-user calls, VRS calls and text relay calls. They can select the appropriate type of relay service depending on the situation at hand, and they can use the same device to communicate with everyone in the community. For example, for the cases when just one party has access to video, the call between native RTT+voice functionality and video calling functionality on the other end is established anyway, and the users can communicate by real-time text and voice.

As discussed in the comments to paragraph 35, functions for automatic speech-to-text translation are improving and as they reach a level of usability that can make it fruitful to use them for functions similar to text relay service and captioned telephony services, or to augment the function of relay services. A first step toward this goal would

be to implement trial projects, prior to the wide deployment of such services. A number of benefits can potentially be achieved, including call experience, turnaround times, flow of the conversation, privacy, and cost. Delivery of the text in real time, and full interoperability of RTT with all relay services, is a prerequisite for full benefit to be achieved.

37. *Advantages Over Messaging-Type Services. Text-based accessibility solutions include RTT, SMS, instant messaging and similar chat-type functions, and e-mail. With the exception of RTT, each of these technologies requires parties to complete their messages and to press "send," "enter," or a similar key to transmit the message to its recipient. By contrast, when a message is sent in real time, it is immediately conveyed to and received by the call recipient as it is being composed. For this reason, several commenters maintain that RTT is the only type of text communication that allows a natural flow of conversation akin to voice telephone calls, and therefore the only form that meets the criterion of functional equivalency. Without the turn-taking and delays characteristic of messaging-type communications, these parties state, RTT gives call recipients "an opportunity to follow the thoughts of the sender as they are formed into words."*

We agree with this view. Evidence is already available from Sweden, as shown in our response to paragraph 36, which confirms this view. Messaging, RTT access and PSTN textphone access have been available in parallel for several years in Sweden. There, RTT access is regarded to be the one providing the best functionality because of the smooth and rapid text handling. The hassle-free use of simultaneous text and speech is also appreciated, considering that the other option has been awkward alternating between text and speech in the old HCO and VCO procedures used with PSTN textphones (TTYs).

38. *In addition to the inability of messaging-type technologies to transmit communications instantly as they are created, the Technology Research Centers note what they consider additional drawbacks of these alternatives: the delivery of messages over SMS is not guaranteed; instant messaging is not interoperable; and certain features, such as conference calling, are not available via instant messaging across multiple providers. Consumer preference for RTT over messaging-type services in conversational situations is also evidenced in field trials conducted by the Trace Center, Omnitor, and Gallaudet TAP. Those expressing a preference for RTT in many of these studies reported this mode to be "more efficient because they could see what the other person was typing in real time" and to be more interactive, in that it provided "a better indication of the other person's feelings and presence." In contrast, messaging-type text methods were described as "slow and inefficient," causing conversations to be "less natural and fluid."*

We agree with this view. It is for example essential in a voice conference call with captioning that the text is provided in real-time. Otherwise, it is not possible for the

participant relying on or voice+text captions to interact in the conference. Message-based transcription would induce significant delays in reading and processing of the contents of the conference by the participant, and destroy any chance at getting the floor. With RTT, there is an opportunity to get the floor and interact with the conference.

However, it is not correct to say that RTT is always preferable to SMS. Different users have different preferences. Even those that prefer RTT for conversation often use SMS for messaging just like people who use voice for communication also use SMS for messaging. But RTT has the advantages discussed above for interactive conversations where a hearing person in the same situation would make a voice call, for emergency calling, and is also essential for captioned telephony and for text-assisted voice conversations for those who cannot speak or hear clearly.

39. *Access to 911 Emergency Services. Perhaps the most compelling case to be made in favor of RTT over messaging-type services is in the context of emergency calls to 911. Recent studies reveal a preference for RTT in simulated emergency situations by 100 percent of participants. According to the Technology Research Centers, a principal reason for preferring RTT over SMS is that the latter can result in "[c]rossed messages [that] can lead to misunderstanding and loss of time. . . . In an emergency situation, a panicked caller may ask a second or third question if there is no immediate visible response from the 9-1-1 call-taker. This can lead to confusion, crossed answers, and error." In contrast, these groups explain, RTT enables "emergency call-takers [to] view the message as it is being typed and respond, refer, interrupt, or guide the information being sent to speed up communication and make it more helpful to emergency responders." In this manner, they say, RTT "allows for the efficient exchange of information and a continued sense of contact," as well as the delivery of even incomplete messages, which can result in potentially saving lives in an emergency.*

We agree with this view.

40. *Verizon notes that "existing LTE standards already contemplate the transmission of RTT 911 with location and roaming capabilities" and asks the Commission "to focus its efforts on developing RTT as a solution for end-to-end next generation 911." Taking such action, it says, would be consistent with Congress's objective, as expressed in the CVAA, to replace legacy TTY technology "with more effective and efficient technologies and methods" that "ensure access by individuals with disabilities to an Internet protocol enabled emergency network, where achievable and technically feasible." The National Emergency Numbering Association (NENA) concurs that RTT "will further enhance the conversational nature of calls, allowing for faster, more accurate communication between telecommunicators and callers, and will better emulate the flow of TTY conversations to which many deaf or hard of hearing users are accustomed." Omnitor adds that the move to RTT will create "an enormous improvement in usability of the emergency service dialogue resulting in good lifesaving opportunities" especially when Next Generation 911*

(NG911) deployment occurs, "because the NG9-1-1 plans contain the same standards for RTT as AT&T describes support for in the rulemaking petition."

We agree with this view. It also reinforces the choice of RFC4103 as the most appropriate standard, because no transcoding would be required at the border to ESINet.

41. We recognize that, two years ago, the Commission adopted rules that could be met through the provision of SMS-based text-to-911 service. The Commission's goal in doing so was to ensure that, in the near term, individuals have a direct and familiar means of contacting 911 via text through mass market communication devices that are already available to people with disabilities and other members of the general public. The Commission noted that some commenters were less supportive of SMS-to-911 because it does not support the ability to "send and receive text simultaneously with the time that it is typed without having to press a 'send' key." At the same time, the Commission recognized that many stakeholders would choose to text to 911 through an interim SMS-based solution because of its ease of use for people with disabilities and ubiquity in mainstream society. It went on to note that RTT "provides an instantaneous exchange, character by character or word by word," a feature that commenters to this proceeding say is critical in an emergency. As this discussion makes clear, the record in the instant proceeding continues to reflect major concerns by several commenters about using SMS as a long term 911 accessibility solution. While we do not propose to make any changes to our existing text-to-911 rules in this proceeding, we believe that our proposals to facilitate the wider availability of RTT for people with disabilities could have a beneficial impact on the future evolution of text-to-911.

While SMS is a very popular option, people will need to be able to use the same communication tool they are using for everyday calls for 911 calls. And they will need to know which tool will work in the emergency case. At the same time, the 911 services cannot be expected to natively support all different and mutually incompatible electronic communication services that are in use among the general public today. NENA has in its NG9-1-1 specifications included a realistically low number of technical standards to support for NG9-1-1 access, including call establishment, audio, video, real-time text and text messages. SMS support in text-to-9-1-1 is important because of the wide spread use of SMS, but it is an extremely slow and awkward medium compared to a call with free flow of voice and RTT. The implementation of current text-to-9-1-1is also very limited, with no opportunity to mix text and voice in the same call, thus not at all satisfying the communication needs of many users.

It should be noted that there are many people for whom speech, not text, is their primary means of communication, even though it does not work well for them on the phone (or even in person). Older adults who are progressively losing their hearing are a prime example of such a group, but they are not the only ones. For them, it is important that they be able to communicate in speech but have any speech that comes back to them be augmented with text to be sure they understand what is said. The population whose hearing loss is too severe to rely on their hearing in an emergency (especially if there is noise) is very large – and expecting them to think of or use a text app for communication in an emergency instead of just calling is not realistic and puts their lives at risk.

There was a fear when the SMS based text-to-9-1-1 was developed, that the fact that it was developed would be taken as a reason to not continue with improved methods to have text calls with 9-1-1. That fear has come true in a number of cases. The argument that SMS to 9-1-1 should be sufficient is seen occasionally, disrupting efforts to work on better solutions with better conversational flow. Work needs to continue to implement the access methods to NG9-1-1 that are included in the NENA i3 specifications for NG9-1-1, including RTT as an important way to reach 9-1-1 together with audio and optionally video.

42. *Based on the comments summarized above, we propose that RTT will be more effective than messaging-type services in meeting the communication needs of consumers with disabilities, including their emergency communication needs. We seek comment on this proposal. Are there other text-based communication solutions that can meet the general communication needs of this population as effectively as RTT, and if so, how? How would the deployment of RTT or other text-based solutions impact the transition to NG911? In response to the Commission's T911 Second Report and Order and Third Further Notice, some commenters raised concerns about the feasibility and costs associated with accepting 911 calls delivered over RTT. However, in its Petition for Rulemaking, AT&T states that the RTT-TTY interworking gateway that it is building into its network will enable individuals using RTT to communicate with all PSAPs without any added costs to the user or the PSAP. We ask commenters to address concerns about the costs, benefits and feasibility of using RTT for accessing 911 services. Similarly, we seek comment on the technical and operational impact on PSAPs receiving RTT-based 911 calls.*

RTT is the only feasible text format in NG9-1-1 that is able to handle emergency calls with both IP users and the remaining TTY users. There are no unmanageable costs related to RTT in NG9-1-1 compared to the transition to NG9-1-1 in general. RTT in emergency services has been successfully tested and verified in interoperability events arranged both by NENA (ICE 5, in 2013), and ETSI using the same specifications for NG112 in Europe (ETSI NG112 Plugtest). User terminals, access networks, emergency service networks, PSAP systems and recording systems all were tested in these events.

The implementation of gateways between RTT and TTY will enable access of TTY users to RTT-equipped NG9-1-1 PSAPs, and access of RTT users to legacy 9-1-1 PSAPs still on a PSTN connection using the TTYs.

However, conversions between TTYs and RTT are not problem-free. The severe functional limitations of the TTYs relative to RTT create risks for loss of information, misunderstandings, and delays. The risks are more severe in the case of RTT users getting routed to legacy 9-1-1 PSAPs that still use TTYs. The EAAC “TTY transition report,” the EAAC "Report on procedures for calls between TTY users and NG9-1-1 PSAPs," and the EAAC report on "Proposed procedures for the TTY as a text terminal in legacy 9-1-1 PSAPs without IP connection" provide information on the limitations and give practical advice on mitigating the negative effects that arise out of these limitations.

The gateways must include procedures to reduce the risk of transmitting text both ways simultaneously, which TTYs are unable to deal with without loss of information, as well as other risk reduction procedures. In addition, the limited character set of the TTY

requires replacement of unsupported Unicode characters from the RTT side with others. This is discussed in more detail in our comments to paragraph 63.

In summary, TTY terminals in the PSAPs may be used for RTT access to 9-1-1, but doing so will require PSAP training to recognize situations where the limitations of TTY interfere with communication, and to take appropriate actions to recover from such situations. Such training should be coordinated with the NENA Accessibility Group. PSAPs also should be upgraded to NG9-1-1 as soon as possible.

VI. Minimum Functionalities of RTT

43. *The DAC recommends that the Commission "consider how telecommunication and advanced communications services and equipment that support RTT [can] provide the users of RTT (either in isolation or in conjunction with other media) with access to the same telecommunication and advanced communications functions and features that are provided to voice-based users of the services and equipment." We believe that this formulation captures the objectives of sections 225, 255, and 716 of the Act, which are to provide functionally equivalent communications and to ensure that telecommunications and ACS are fully accessible to and usable by people with disabilities. Accordingly, we propose that, in amending our rules to recognize IP-based text alternatives and facilitate the transition away from TTY technology, we should consider the extent to which RTT's features, functions, and capabilities can provide people with disabilities with telephone service that is as accessible, usable, and otherwise as effective as voice-based services over IP networks. We seek comment on this proposed approach.*

This approach is essential to including this group in telecommunication, especially if interoperability and harmonization between RTT solutions are required from the providers of services with RTT.

For example, many places answer with a robot receptionist. If it will work with voice but not RTT, then the individual is essentially barred from calling that store. Others send callers to a voicemail system rather than a person, a message is taken, then they call back. Again, if the caller is unable to leave messages, communication with this place or person is prevented for a person who cannot use or hear speech clearly. They

can't even understand the instructions for leaving the message. It is said that we will be moving more and more to the use of electronic agents who can communicate through speech - moving us further toward the need for all related telecommunication services, with people or pseudo-people and voice operated services to equally available. The presence of a human on the other end should not be the test of when RTT should be supported if we are going to consistently replace humans with voice interaction robots (some of whom are now becoming indistinguishable from humans).

44. *In this section, we tentatively conclude, propose, or seek comment on basic functionalities that we believe are necessary for a wireless provider's implementation of RTT to be considered compliant with the rules adopted by the Commission in this proceeding. Specifically, we seek comment on the extent to which each is necessary to achieve effective telephone access for individuals with disabilities, as well as its costs, other benefits, and any technical or other challenges that may be associated with its provision. Finally, we seek comment on the extent to which each of these features will be enabled or facilitated through the use of RFC 4103.*

A. Interoperability

45. *We tentatively conclude that people who rely on text to communicate can only achieve effective RTT communications across multiple platforms and networks if the communication transmissions carried across, and the terminal equipment used with, those platforms and networks are interoperable with one another. We seek comment on this tentative conclusion. We note that there is consensus among commenters on AT&T's petition for rulemaking with respect to the need for seamless interconnection of RTT services across networks, service providers, and devices. Virtually all commenters agree with AT&T on the importance of not locking users into a single network, service provider, or device, as well as the value of "ensur[ing] that people with disabilities have the same kinds of choices in a competitive market as the population in general." Trace et al. note that "[t]he benefits of a communications system increase greatly as more users and services can be reached by it." They report "overwhelming agreement" among the participants in their field trials on the importance of RTT interoperability across different devices and technologies, including legacy TTYs, so that RTT users can make calls regardless of telephone system or carrier, can reach every telephone number, and can enjoy the same flexibility and choices as everyone else.*

We agree with this assessment.

46. *Consumer Groups note that if service providers were to adopt proprietary standards that do not interoperate, RTT users might not be able to communicate with other users in emergency situations. Similarly, TIA states that "for RTT technology to successfully support the emergency communications needs of consumers with disabilities, interworking functionality must be developed"; accordingly, TIA urges the Commission to adopt rules that "focus on ensuring interoperability among all parts of the RTT system." Likewise, Verizon states it will develop and deploy RTT technology that will be "accessible, interoperable with other RTT services and applications, and compatible with other providers' networks. . . ." Making the same commitment,*

AT&T asks the Commission to deem RTT functionality in compliance with the Commission's TTY support requirements only if its implementation is interoperable with other VoIP networks.

47. *Commission rules reflect a longstanding commitment to policies favoring the openness of telecommunications services across providers and devices, so that anyone can make a voice call to anyone else, regardless of the provider or device they are using. For example, the Commission has promulgated a series of rules to ensure the interconnection of terminal equipment to the telephone network. Our rules also prohibit telecommunications carriers and ACS providers from installing "network features, functions, or capabilities" that impede the accessibility or usability of telecommunications and ACS services. Further, in the Emerging Wireline Order and Further Notice, the Commission tentatively concluded that a carrier seeking to discontinue an existing retail communications service in order to transition to a newer technology must demonstrate that the replacement service offered by that carrier, or alternative services available from other providers in the affected service area, provides voice and non-voice device and service interoperability – including interoperability with third party services – as much as or more than the interoperability provided by the service to be retired. We believe that preserving interoperability is equally important in the transition from TTY to RTT technology. We further believe that, in the absence of interoperability, multiple versions of RTT may need to be supported, not only by user devices, but also by TRS call centers and 911 PSAPs – a burden that could entail a prohibitive expense for many such entities. We seek comment on this analysis.*

We agree with this analysis. A situation similar to the current situation in text messaging services, where a plethora of mutually incompatible formats exist, could appear if harmonization and interoperability for RTT is not intensively encouraged and enforced. A similar situation for RTT services is not desired.

48. *We next consider how best to achieve RTT interoperability across communication platforms, networks, and devices. Consumer Groups maintain that having a single standard will "ensure that, from day one, RTT is a valuable and universally usable communications medium." They suggest that it will be less expensive for carriers to develop and deploy a single, interoperable RTT system now, than to each develop their own versions of RTT service and later try to reconfigure these to be interoperable. The Technology Research Centers add that because "the IP voice communication infrastructure is rapidly being deployed," early adoption of a common standard is necessary to facilitate support throughout the system and avoid having to later retrofit an installed base of equipment.*

49. *Industry associations, on the other hand, argue that it is premature to adopt a mandatory common standard for RTT at this time. CTIA contends that additional standards development and implementation are necessary before a single standard can be selected, given that "there are a number of possible implementation solutions" and "several technical standards" that could be used to implement an RTT solution. Instead, CTIA recommends that the Commission adopt performance objectives, akin to those established to implement the Act's mandates for telecommunications and ACS accessibility. TIA similarly encourages the Commission to allow flexibility in the implementation of RTT and, while acknowledging the need for interoperability, urges the Commission not to mandate specific technological solutions to achieve this.*

50. *Consumer Groups respond that the adoption of a standard would set "a floor, not a ceiling," and that doing so would not prevent companies "from innovating and providing greater functionalities" than are specified by the standard. They also point out that the lack of a common standard sometimes has impeded the interoperability of communications technologies needed by people with disabilities. For decades, they report, the lack of an international standard for TTY technology has prevented TTY users from communicating by text in real-time with people living or*

visiting countries abroad. Similarly, according to Consumer Groups, the lack of a common standard for instant messaging sometimes prevents instant messaging (IM) users from being able to contact each other across IM platforms. Likewise, the Technology Research Centers explain, the lack of a common VRS standard has impeded full interconnection for users of this service since the early 2000s.

51. *We agree with consumers and researchers that standards can be especially important to ensuring interoperability of technologies needed by people with disabilities and that common technical specifications will allow connectivity to occur seamlessly from one end of the call to the other without incurring obstacles along the way. At the same time, we acknowledge the need for the Commission's rules to incorporate "key principles of flexibility and technology neutrality" as recommended by industry commenters. We tentatively conclude that a middle ground between these two approaches can be achieved by referencing a technical standard as a safe harbor. We believe that this approach will ensure RTT interoperability and product portability, while at the same time provide sufficient flexibility for covered entities adhering to different internal RTT standards – so long as their RTT support offers the same functions and capabilities as the selected standard, and is interoperable with the standard's format where they connect with other providers. We seek comment on this tentative conclusion and analysis.*

The Safe Harbor principle seems suitable for achieving interoperability between RTT users within one service provider and between service providers. RFC 4103 has sufficient functionality, scope and applicability to be named the Safe Harbor standard for RTT.

However, it must be defined what is implied in the interoperability requirement. The interoperability requirements need to be split into call interoperability requirements and device portability requirements.

The following seems suitable as targets for call interoperability by having real-time text communication in the following situations:

- Ability to call and be called by users of the same service provider.
- Ability to call and be called by users of other service providers who provide interoperability for voice.
- Ability to call and be called for international calls with users of providers that provide voice interoperability.
- Ability to call and be called by TTYs connected to PSTN.

- Ability to call and be called by NG9-1-1 emergency services who have RTT support.
- Ability to call and be called by VRS and text relay and captioned telephony services

Another class of interoperability is the device portability. A portable device can be moved between different service providers' networks and be made work in that new situation. The device portability may have limits to a specific group of technologies. It is only feasible to require device portability for RTT-capable devices to the same degree as the base technology for communication in other media provide. (for example, if wireless LTE handsets can be moved between carriers and voice works after the move, then also RTT functionality provided by these carriers shall work after such move.) Thus, the *portability* requirement needs to be made separately and cannot be made quite as general as the *interoperability* requirement.

Because of the many aspects of interoperability, it is essential that the FCC more exactly defines how the Safe Harbor principle shall be applied on RTT. Any approach that allows for incompatibilities between the RTT implementations of various carriers should be prohibited, as it would preclude RTT interoperability on a practical level.

52. *To the extent that any commenter believes that reference to a safe harbor standard is unnecessary, we seek comment on how we can otherwise ensure that RTT communications are interoperable, not just among different implementations of RTT, but also with legacy interconnected TTY devices. In this regard, we note that the DAC asks whether RTT would remain an acceptable alternative to TTY technology "in the absence of conformity of networks and equipment to a common standard." Likewise, we ask commenters who support adoption of a mandatory technical standard to explain why a safe harbor, combined with performance objectives, would be insufficient to achieve effective and interoperable RTT communications. Further, will a safe harbor be sufficient to provide incentives for manufacturers and providers to invest in research and development of RTT functionalities?*

53. *For the reasons discussed below, we tentatively conclude that RFC 4103 is the appropriate standard to which covered entities should adhere as a safe harbor, conformity with which should*

be deemed to satisfy our interoperability requirements and certain of our performance objectives for RTT communications. We seek comment on this tentative conclusion. Use of RFC 4103 for RTT communications is well supported by the record to date, as reflected in the comments on AT&T's petition for rulemaking. First, RFC 4103 is a non-proprietary, freely available standard that has been widely referenced by leading standards organizations. As various commenters have pointed out, this standard, developed by the IETF, has been adopted by the International Telecommunications Union Telecommunication Standardization Sector (ITU-T), the European Telecommunications Standards Institute (ETSI), 3GPP, a partnership of seven telecommunications standards organizations, and Groupe Speciale Mobile Association (GSMA).

We agree that RFC 4103 is appropriate for this purpose, and there is no other standard or specification suitable to take this role. It should however be noted that RFC 4103 requires transportation by the Real Time Protocol (RTP) RFC 3550, and is therefore applicable for provider-internal use only in technologies where it is possible to add an RTP stream for RTT. In environments where it is not technically feasible to use RFC 4103, the provider can use another technology to implement real-time text (see also our comments to Paragraph 57); however, the provider shall use RFC 4103 as the safe harbor standard for interconnection of calls with other providers and other calls according to the description of call interoperability provided in the answer on point 51 above. Further – the provider will require support for this other form of real-time text by terminals it creates or certifies for connection to its service. Finally this other form of real-time text shall conform to the provisions worked out by the Access Board's joint industry-consumer Telecommunications and Information Technology Advisory Committee.

54. *Second, RTT is already being used or has been widely designated for implementation by numerous carriers and other organizations, both domestic and foreign. Domestically, both AT&T and Verizon have specified RFC 4103 as the standard protocol to be implemented in their IP-based wireless networks as the successor to TTY technology, the National Emergency Number Association has specified RFC 4103 for interoperable use in IP-based Next Generation emergency text communications where SIP technology is used, and the Access Board has proposed requiring RFC 4103 for federal procurements associated with the transmission of SIP-based RTT to achieve compliance with section 508 of the Rehabilitation Act. In addition, RFC 4103 is specified in the SIP Forum's interoperability profile for VRS providers.*

55. *Trace et al. note that outside the United States, RFC 4103 has been implemented in text or video relay services in France, the Netherlands, Sweden, and Norway. They further report that "[a]t least four communication technology providers and a number of communication service providers in Europe are providing terminals, terminal software, communication services, interoperability*

with other providers, interoperability with legacy PSTN text telephones, answering machine services, relay service access and emergency service access all using RFC 4103."

56. *Third, according to commenters, RFC 4103 has a number of features that make it particularly suitable for RTT. According to the Technology Research Centers, RFC 4103 eliminates the need to transcode at the borders of a network, permits a wide range of hardware, supports the international character set (Unicode), has built-in redundancy, is bandwidth efficient, is based on the same transmission protocol (RTP) as audio and video, and is supported by existing open source and commercial codecs. We seek comment on the value of each of these features and the extent to which they can contribute to making RFC 4103 a feasible and flexible means of achieving RTT interoperability and functionality. We also seek comment on which of the user functionalities necessary to an effective communications system, in addition to interoperability, can be made possible with adherence to RFC 4103. Further, to what extent can other RTT standards "coexist" with RFC 4103 in networks, technologies, and terminal equipment on which RTT is being used, to allow RTT to provide a universally accessible communications environment for people who are deaf, hard of hearing, speech disabled, or deaf-blind?*

Here is a list of the features and comments on their use:

- **Transcoding.** Transcoding between different formats (e.g. ASCII and Baudot) is an activity that is not desirable. It adds delays to transmission, it risks the introduction of inconsistencies in the presentation of media and it complicates network architecture and call setup. But it is possible and sometimes inevitable. The wider a single standard is used, the fewer cases of calls that will need transcoding. Therefore it is of great benefit that as many providers as possible use the same coding standard for RTT. RFC 4103 provides a good way to keep the amount of transcoding low because it is widely referenced in various environments.
- **Hardware.** RFC 4103 is implementable in the modern implementation environments where VoIP communication is implemented. In the network, it does not require its own servers or other components, but can be conveyed by the same hardware as VoIP media in the calls. This makes implementation uncomplicated. Other RTT technologies often require their own servers for

conveying the real-time text. Such architectures are more complex to set up and maintain and may cause transmission delays.

- **Character set.** RFC 4103 makes use of the Unicode character set, which is intended for consistent transmission and presentation of characters in all written languages and a large number of additional symbols, such as emoticons. This eliminates the risk for mismatch between the presentation at the sending and receiving side as can happen in systems allowing multiple character sets (unless they are all required to be supported by all systems and devices). It also enables deployment anywhere in the world, and allows use between persons with other native languages than English and Spanish (both domestically and internationally). There is no strict requirement in RFC 4103 or its presentation standard ITU-T T.140 to be able to send and present the complete Unicode character set, but many modern devices can do so, and therefore enable this possibility without extra effort.
- **Redundancy.** Communication errors can appear in any communication system, and the IP networks are designed with this as an assumption. For voice, dropped data is accounted for by smoothing the data received around the missing data. This is not possible with text – so other forms of recovery from data loss are required and build into every text communication technology. The primary method to make the RTT text transmission robust and resilient against communication errors is to use redundant transmission of all text three times with a span in time between the transmissions. This is a very efficient way to achieve robustness for text, which is a medium with low

volume. (Three times text transmission is less than one-time transmission with voice). Communication only needs to work in one direction for this scheme to work. If the data disruption is so severe that errors appear anyway, a mark is inserted in the text to alert the user that something may be missing at that point. Other means of ensuring transmission even more can be applied as options in RFC 4103 , but they would delay communication and have not been regarded as being frequent or important enough to engage. Tests done by Gallaudet University in collaboration with AT&T showed that RFC 4103 worked with minimal loss of characters all the way up to 20% packet loss, and all such lost characters were clearly marked. Intelligibility was unaffected. In contrast, at 20% packet loss for voice calls, a recent study by Gallaudet University found that even hearing participants exhibited impaired speech understanding: on the Harvard sentence set, only 83% of words were understood on average for narrowband audio, and 91.5% for wideband audio[3]. This finding indicates that under adverse network conditions, RFC4103 with redundancy may also result in fewer misunderstandings compared to voice communications for everyone – no matter whether deaf, hard of hearing, or hearing. It should be noted that even though RTT via RFC 4103 remained viable longer, it consumed much less bandwidth in the process (less than 2

[3] Kozma-Spytek, L., Tucker, P., Garvert, M., Vogler, C. (2016). AT&T Final Report. Filed with the FCC, GN Docket 13-5, April 7, 2016. Online: https://www.fcc.gov/ecfs/filing/60001535773 (Last accessed: 7/11/2016)

kBit/s for text vs 5.95 and 12.65 kBit/s for narrowband and wideband voice, respectively).

- **Bandwidth efficient.** Text for human communication is a low volume medium. However, the need for transmission in short intervals to maintain the real-time view of RTT can cause quite large bandwidth consumption if the technology for text transmission is not properly selected. That in turn can cause quality problems for voice communication and cost for users and providers. RFC 4103 is designed to use low bandwidth and relatively low frequency of transmission, so that it only loads the connections with a fraction of what is used for audio or video communication. RFC 4103 often consumes less than 2 kBit/s for English, and it is seldom that RFC 4103 consumes more than 6 kbit/s and sends more than 3 packets per second. All this is with the redundancy mentioned above.[4] This compares favorably with audio: On fixed-line calls, audio commonly is transmitted at 50 packets per second and consumes about 40-80 kbit/s. On wireless calls, it commonly is transmitted at 50 packets per second, and consumes 5.95 to 12.2 kBit/s for narrowband audio, and 12.65 kBit/s for wideband audio. This makes RFC 4103 appropriate to use by many users without causing any huge extra load or transmission cost.

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[4] See RealTimeText.org FAQ, "What is the expected bandwidth usage of Real-Time Text in a SIP call (RFC4103)?" Online: http://realtimetext.org/FAQ (Last accessed: 7/11/2016)

- **Same transport as audio and video.** RFC 4103 is based on the Real Time Protocol (RTP), which is the same transport used for most VoIP (and video) calls. That makes the addition of RTT to a VoIP implementation relatively easy, because the base technology is already in place in a communications device. The negotiation that takes place at the beginning of a call to decide on media and transport details for RTT would therefore be the same mechanisms used for audio and video. The common protocol used for specification and negotiation of media details; Session Description Protocol (SDP) is often required by higher level general standards for general functions, such as invocation of conference bridges and selection of media and codecs in a session. Again RTT (RFC4103) is easily added to already established designs by extending the use of SDP for the added media stream. Thus the RTT transport used by RFC 4103 enables wide deployment in a flexible way.
- **Support.** The widespread support and specification of RFC 4103 for real-time text in standards, specifications and services makes it the natural candidate for a safe harbor requirement, causing as little extra work as possible to establish interworking.
- **User functions.** The user functions made possible by requiring RTT implementation and using RFC 4103 as safe harbor are many. Just to mention a few:
    - Real-time text conversation with good flow, robustness and interoperability among a large number of service providers, users and services.
    - Addition to audio in calls at any point in the call.

- Allows addition of video in calls using the same mechanisms.
- Multi-party conferencing with RTT support.
- Interoperability as specified in point 51.
- Type and correct the typed text.
- Correct also recently finished text entries
- Text creation by speech-to-text technology, sip-and-puff, alternate keyboards or any text generation method
- Transmission of emoticons mixed with text while using just Unicode
- Use by users with varying written languages both domestically and internationally.
- Provision by the dominating carriers because of its low resource usage.
- Braille display for deafblind persons and users with low vision.
- Text-to speech operation. Read out text.
- Use for main or complementing communication with relay services
- Occasional use by the general public for explaining words or spelling or noting items in need to be remembered or for exact spelling
- Occasional use by sign language users in video calls for the same reasons
- Control of multimedia answering machines, voice mail, text mail and video mail
- Ability to be used with automated receptionists, voice menus at companies or stores (e.g. "for hardware press 1) in ways that can provide access to those who cannot hear well, and actually speed their use by all users.

57. *Next, we seek comment on whether RFC 4103 is sufficiently flexible to "spur innovation in accessibility solutions." Are there any non-SIP-based networks for which implementation of RTT would serve the public interest, and if so, how could RTT be implemented on such networks so as to be interoperable with networks adhering to RFC 4103? Finally, if any adverse effects would result from adopting RFC 4103 as a safe harbor, we ask commenters to identify these, and to explain specifically how such effects could be mitigated by modifying the standard or allowing an alternative protocol.*

Yes – it is in the public's interest for there to be RTT on any environment where there is voice communication. Otherwise people who need RTT or RTT+Voice will be precluded from participating in those business, education, social, voting, and other kinds of environments.

There are call control protocol environments (called "networks" in point 57) where other RTT solutions than RFC 4103 seem more natural. In these situations the Safe Harbor requirement should require support of RFC 4103 at the borders of these 'networks'

where they connect to other 'networks' where RFC 4103 can be supported - for interoperability with other providers and services.

Since many of these environments are proprietary is it appropriate for the owner of the environment to be free to define the RTT format to be used in that environment - and to name/ define that format - as long at that format is a reasonable RTT format as defined below. For those that are defined by other standards processes, the organization creating the standards for the environment would identify the RTT format that would be named/required for that environment. Once named, that format would be the 'safe harbor' format for that environment. Any voice over IP device connecting to that other environment can conform by supporting the RTT safe harbor format for that environment Where that environment connects to a SIP environment for voice, that environment would also convert its "safe harbor" RTT format into the SIP environment's safe harbor format, RFC 4103.

In non-SIP environments, the RTT format requirements should be a quality, low error RTT that interoperates with RFC 4103 where the environment connects to a SIP environment.

More specifically, we suggest these requirements: :

1) The "Safe Harbor' for SIP environments shall be RFC 4103 (the RTT format SIP defined by IETF who defined SIP).

    - Because SIP is the backbone and needs a defined standard for others to work to, and to get this going and remove ambiguity the FCC recognizes this defacto standard for RTT on SIP, and declares it the "Safe Harbor" RTT standard for SIP environment. .

2) Each other non-SIP environment must determine the real-time text “safe harbor” format for that environment. (Determined by the owner of the environment … the company or standards group that owns or defines that environment

- The “safe harbor” real-time text format shall meet the minimum requirements which include:
    - character error rate below .2 % under 3% packet loss, which is a common upper bound for managed networks
    - Text and voice can be transmitted in parallel and in both directions simultaneously (four channels simultaneous)
- all devices (e.g gateways or terminals) in that environment shall support that "safe harbor" technology for that environment. If they do they will be in conformance with the FCC rule.
- All connections between this environment and a SIP environment shall support the SIP environment "safe harbor" technology

Examples of other VoIP environments are:

- Jingle (XMPP)
- WebRTC
- Skype
- Cable phone systems
- Other proprietary interconnected non-SIP VoIP solutions

The organization defining each environment would be free to determine the specified “safe harbor” RTT standard for their environment

58. *In the event that the Commission decides to adopt RFC 4103 as a safe harbor for RTT, we seek comment on how this standard can be updated and amended to accommodate successor non-proprietary RTT technologies that are developed in the future. The Technology Research Centers point out that the path for incorporating innovations into RTT can be the same as that used to update voice standards and codecs, i.e., by phasing in new formats and technologies while continuing to support the existing technology until its retirement. How can we design our rules to allow these capabilities to continue evolving with technological advances and ensure the flexibility requested by industry, while not compromising the effectiveness of this technology for people with disabilities?*

RFC 4103 is selected to be used in the calls through negotiation with the Session Description Protocol SDP. Such negotiation and selection procedures are very commonly

used for selection of media coding standards. It is realistic to expect that any future modifications from RFC 4103 or new alternatives are selected by such procedures, so that parties implementing the new protocol can select it and parties having the initial safe harbor standard selects that protocol.

New real-time text protocols could be introduced in the same way new audio codecs are introduced. The new protocol is introduced in parallel with the current "safe harbor" protocol – **and all new technologies are required to support both.** Because all devices and systems support both, people, systems, and devices are free to use the new protocol for the call as long as everything from one end to the other supports the new protocol. If not then the call can fall back on the existing mandatory "safe harbor" protocol. At some point, everything in use everywhere will support both the new and the old protocols as all of the old technologies (that do not support the new protocol) become obsolete and fall out of the market. Once all of the technology in use supports the new protocol, the old one becomes 100% redundant and can be dropped. As noted above, this is how it is done with voice codecs. In voice communication devices today it is common to have many voice codecs be required by a network with older codecs only being dropped when all devices supporting some codec that becomes the new “fallback” or default codec. Thus there are no devices that would be left unable to communicate (except antiques that are not in regular daily use).

In this way, new methods for RTT can be phased in, with the initial required protocol (RFC 4103) kept as long as it is needed to assure interoperability. This approach can also be used by companies internally – and externally.

59. *We believe that we have sufficient authority to adopt RFC 4103 as a safe harbor. Section 716 explicitly allows the Commission to "adopt technical standards as a safe harbor for such compliance if necessary to facilitate the manufacturers' and service providers' compliance with section [716] (a) through (c)." Additionally, section 106 of the CVAA expressly authorizes the Commission "to promulgate regulations to implement the recommendations proposed by the EAAC, as well as any other regulations, technical standards, protocols, and procedures as are necessary to achieve reliable, interoperable communication that ensures access by individuals with disabilities to an Internet protocol-enabled emergency network, where achievable and technically feasible." We seek comment on this analysis. Further, we ask commenters who support a mandatory standard to provide legal authority for their proposal. CTIA points out that section 716 of the Act does not permit the Commission's regulations implementing that section to mandate technological standards, except as a safe harbor to facilitate the manufacturers' and service providers' compliance with section 716. At the same time, as noted, section 106 of the CVAA expressly authorizes the Commission to adopt technical standards to ensure access by people with disabilities to an IP-based emergency network. In the event that the Commission deems it necessary to adopt a mandatory RTT standard, would our specific standard-setting authority under section 106 of the CVAA, as well as our authority under section 225 of the Act, provide sufficient authority for the Commission to establish a mandatory technical standard for RTT, notwithstanding the standard-setting restriction of section 716?*

B. Backward Compatibility with TTY Technology

60. *The DAC points out that while TTY usage continues to be in steady decline, some people who are deaf, hard of hearing, deaf-blind, or speech disabled, including senior citizens and rural residents, continue to rely on TTYs. In addition, some places of public accommodation currently offer TTYs or TTY access as their sole method of text-based communications access, and some may continue to do so even after RTT is deployed. Other parties to this proceeding note that TTY technology continues to be used by individuals who do not have or cannot afford high speed Internet access or who rely on certain forms of TRS. Consumer Groups also caution that some persons have kept their TTY devices to make emergency calls. In a survey conducted by Trace et al., ninety-six percent of respondents agreed on the importance of being able to interconnect TTY and IP-based RTT conversations so that TTY users would not be left behind during the migration to RTT.*

61. *In order to avoid "sacrificing existing accessibility solutions as carriers and customers transition to RTT," AT&T proposes requiring IP-based wireless service providers to achieve backward capability with TTY technology as one of two requirements for launching RTT. Both AT&T and Verizon have indicated their intent to use RFC 4103 to achieve such compatibility. AT&T explains that an RTT-TTY "interworking gateway" being built into its network will enable RTT users to communicate with TTY users, without any added costs to the TTY user or PSAPs. Likewise, Verizon has conveyed its plans to conduct "batteries of formalized, systematic tests" to ensure that its RTT technology can work with the existing base of TTYs both within its network and between Verizon's network and other provider networks, and notes that initial testing use of RFC 4103 for this purpose has produced successful results.*

62. *In order to ensure that TTY-reliant consumers continue to have a method of communicating during the transition to RTT technology, we propose that, to comply with the rules adopted in this proceeding, wireless service providers must ensure that their RTT technology is interoperable with TTY technology. We seek comment on this proposal. Among other things, with this requirement, we believe it will remain possible for consumers to use their TTYs to communicate with a TRS call center that is set up to receive RTT calls and for consumers who use RTT technology to communicate with a TRS call center that is set up to provide traditional TTY-based TRS. The Technology Research Centers further explain that to achieve compatibility with TTY transmissions, VoIP networks or terminals only need to ensure that, when these networks or terminals connect to the PSTN for voice calls, gateways can transcode between the RTT and TTY formats. We seek confirmation on whether it is feasible to use gateways and RFC 4103 to achieve backward compatibility, and if not, how transcoding between RTT packets used with IP-based*

services and TTY Baudot tones can be achieved, in accordance with the accuracy criteria we propose for RTT. Is AT&T correct that such interoperability can be achieved without added costs to TTY users and PSAPs? We ask commenters to discuss the costs, benefits, and technical feasibility of using any alternative standards for this purpose.

The proposed approach for RTT/TTY interoperability is feasible. The approach is required in procurement requirements from RTT providers in Sweden, where gateways between RTT and V.21 textphones are deployed and work well. The corresponding service would also be feasible in USA between RTT and TTY and have been demonstrated. The huge gap in functionality between RTT and TTY causes some concerns for how to best do the conversion, which we expand in subsequent paragraphs. Another concern is that gateway resources should not be wasted on calls where there is no likelihood for the need for this interoperability function. Very few of the calls will have a TTY connected on the analog side and RTT on the IP side. 3GPP has a suitable method for invoking gateway only in calls where there is some likelihood that RTT/TTY interworking is needed. This gateway is also needed for the case when RTT users call 9-1-1 and end up in a legacy PSAP with TTY.

63. *A particular concern regarding backward compatibility with TTYs is the fact that TTYs can only send and display a small subset of Unicode characters, namely upper-case letters, numbers, the pound and dollar signs, and some punctuation marks. Thus, gateways between RTT systems and legacy TTYs need to be able to convert the much larger Unicode set used with RTT into readable TTY characters. In general, such character conversion is called "transliteration." Thus, accented characters may be rendered as multiple characters – e.g., "ä (a umlaut)" may become "AE." In some cases, words must be used in the transliteration, but all Unicode characters can be described unambiguously, if necessary, by their Unicode character name. According to the Unicode Consortium, transliterations should be standard, complete, predictable, pronounceable, and reversible. Should our rules require a standard transliteration approach or standard table, or should each entity responsible for offering gateways between RTT and TTY choose its own transliteration approach? What standards should be referenced? If each gateway may choose its own transliteration approach, should it meet, for example, the general transliteration guidelines formulated by the Unicode Consortium or other standards body? Should there be a standard indicator that a character string is a Unicode emoji, e.g., "(* GOLFER *)" for Unicode U+1F3CC? With respect to PSAPs employing TTYs, what impact might transliteration have on PSAPs' ability to handle the RTT 911 call?*

It is not possible and not feasible to arrange for a lossless transliteration between RTT and TTY. The only feasible approach is a best effort transcoding combined with

informing the RTT user that the call is in contact with a TTY. The reasons are that the TTY is so slow, only presenting about 5 characters per second. If Unicode transliterations are used, it could result in characters expanded to strings taking many seconds to transfer, and that would block progress of the call. In a true transliteration, even capital vs lower case would need to be transliterated, because in certain conditions that difference is essential. That would in turn result in quite unreadable text on the TTY.

As a concrete example, the nine-character string "Κρυστάλλω" would be transliterated as "(capital kappa) (rho) (ypsilon) (sigma) (tau) (alpha accent) (lambda) (lambda) (omega)", which would take many seconds to transmit on a TTY and would not be readable in any form for the TTY user in the first place.

We suggest following the ITU-T Recommendation V.18, where table A.2 contains recommended transliterations from the most common characters used by RTT users in USA to TTY. The topic is also covered in the EAAC reports. See EAAC TTY Transition Report, and EAAC Report on proposed procedures for TTY as 9-1-1 PSAP text terminal. Accordingly, characters that can not be represented should be transliterated to an apostrophe (') to indicate that something is missing there.

The information provided to the RTT user that there is a TTY in the other end of the call can be used by experienced RTT users to adapt to the communication limitations of the TTY. The gateway shall also support methods for reducing risk of communication failure because of the limitations of the TTY.

64. *We also seek comment on whether there are other assistive devices used with the PSTN, such as Braille-capable devices used by people who are deaf-blind, that would require or benefit from backward compatibility, and what additional steps are necessary to achieve this, beyond the steps necessary to achieve backward compatibility for TTYs.*

There are TTY compatible terminals used by deafblind users. They would become interoperable with RTT via the RTT/TTY gateway. Extra efforts are needed to make RTT terminal types themselves suitable for deafblind users. Some efforts in that direction have already been taken on existing RTT terminals. FCC encouragement and support of such efforts to make sure that devices that support RTT will also provide that text to braille displays, as well as best practice guidelines for doing this would be fruitful.

65. *Finally, we seek comment on what events or measures should trigger a sunset of the residual obligation for wireless networks to be backward compatible with TTY technology. In the CVAA, Congress explicitly asked the EAAC to consider "the possible phase out of the use of current-generation TTY technology to the extent that this technology is replaced with more effective and efficient technologies and methods to enable access to emergency services by individuals with disabilities." The EAAC recommended against "imposing any deadline for phasing out TTY at the PSAPs until the analog phone system (PSTN) no longer exists, either as the backbone or as peripheral analog legs, unless ALL legs trap and convert TTY to IP real-time text and maintain [Voice Carry Over] VCO capability." Since then, however, the DAC has requested the Commission to "consider a TTY sunset period when declining wireline TTY minutes reaches a certain threshold to be determined, while addressing the needs of people who are deaf-blind, speech disabled, and have cognitive impairments as well as for relay services and rural access." Consumer Groups also request that RTT remain backward compatible with TTY technology until the latter is no longer in use.*

As long as there are people whose only connection to telecom is via the PSTN there will be a need for TTY support because it is the only technology that works on the PSTN. If the FCC is looking a for sunset trigger for TTY support, it would be the day that no-one is dependent only on the PSTN for telecom.

We strongly support any effort to eliminate the PSTN as a sole point of contact for anyone and join consumer and industry in the desire to make TTYs obsolete. But this is not possible, unless people who need text to communicate have some other method to connect than the PSTN.

We note above that people who "are deafblind, speech disabled, and have cognitive impairments" are separated from people who are deaf and hard of hearing in question 65.

We suggest that people who area hard of hearing and deaf face the same problems if they have only PSTN connections. And we suggest that people who "are deafblind, speech disabled, and have cognitive impairments" can make use of RTT if it is available to them, and devices tuned to their needs are much easier and would cost less on IP and RTT than they were with PSTN-TTY technologies and Baudot.

We do encourage the FCC to work toward moving all of America to IP networks and to all of the benefits that it would bring. But until the PSTN is gone, there are no current solutions other than the TTY for people who are only on the PSTN and who need text.

66. *We note that the NG911 Now Coalition has set a goal of transitioning to nationwide NG911 by the end of 2020. We seek comment on whether this is an appropriate benchmark for terminating the requirement for backward compatibility, or whether a different indicator should be used to make this determination. Would it be more appropriate for the Commission to set the end date based on TTY usage falling below a threshold level? If the latter, should TTY usage be assessed based on usage of TTY-based forms of TRS, or a different indicator? We are concerned about ensuring that people with disabilities continue to have a means of using text to make emergency and non-emergency calls after a TTY phase-out and generally seek comment on safeguards needed to address these communications needs.*

With respect to a threshold level, we only ask the question: How would people on the PSTN communicate with people who are not on the PSTN if some termination date for interconnection were chosen other than the end of the PSTN? Would we decide (for voice callers) that when the number of voice callers got below a certain level that we would just drop analog phone service without providing IP service to replace it. If such a process is deemed inappropriate for voice, why would we use such a decision process for supporting people who must use text?

We are cognizant of the increasing cost and decreasing cost/benefit ratio as analog phone use drops and TTY use drops with it. But if it is the only connection for these people, do we want to drop them?

We suggest that concerted thought be turned to ways to provide connections to these last TTY users so that – as they become scarcer, or their use of the service decreases, we find some way to keep them connected through ways other than maintaining the TTY compatibility. That would be best for both them and the industry.

C. Other RTT Functionalities for Wireless Services

67. *In addition to ensuring interoperability, in this section we seek comment on a number of other features and capabilities that we believe will be necessary to ensure that RTT is as accessible, usable, and effective for people with disabilities as voice telephone wireless service is for people without disabilities.*

68. *As a preliminary matter, we propose that wireless service providers and manufacturers be required to configure their networks and devices so that RTT communications can be initiated and received to and from the same telephone number that can be used to initiate and receive voice communications on a given terminal device. Among other things, we tentatively conclude that enabling access to ten digit telephone numbers is necessary to reach and be reached by any other person with a phone number, and to ensure that RTT users can access 911 services. We tentatively conclude that a similar ability is an essential part of the provision of RTT, and seek comment on this tentative conclusion and proposal, including its costs, benefits and technical feasibility.*

We agree that RFC 4103 based RTT is well integrated with the wireless calling system, and phone numbers can be used. Cost for deployment will appear, and the wireless carriers need to follow the standards for invoking the RTT/TTY interworking functions in a way that does not cost too much in resources on every call. RTT use will only be possible when the device has IP access, and even further limitations in what type of IP connection it has before RTT can be enabled. We recognize that depending on VoLTE and RTT deployment rate, there will be situations when the device does not have coverage with the right kind of IP access and therefore RTT not being available, while voice users still can fall back to circuit switched access on the same device.

69. *As the Commission has previously stated, "[t]he ability of consumers to contact 911 and reach the appropriate PSAP and for the PSAP to receive accurate location information for the caller is of the utmost importance." Given our longstanding commitment to ensuring effective emergency communications, we propose that the implementation of RTT in IP networks must be capable of transmitting and receiving RTT communications to and from any 911 PSAP served by the network in a manner that fully complies with all applicable 911 rules, and seek comment on this proposal.*

Are specific measures or rule amendments necessary to ensure that RTT supports legacy 911, text-to-911, and NG911 services? Given that RTT is in an all-IP environment, and that there may be outages during a loss of commercial power, or RTT may be unavailable due to the limited battery backup inherent in IP-based equipment, are there additional ways to ensure continued access to emergency communications in the event of a power failure to the same extent this will be guaranteed for voice telephone users?

The concept "text-to-911" has so far meant SMS-to-911. There must be a clear decision if the term shall be extended to also include real-time conversational calls with RTT and voice. In fact, it is desirable to not use the vague “text to 911” term and instead use SMS-to-911 and RTT-to-911 so that it is clear what is being talked about at any time – and a requirement for RTT-to-911 is not claimed to be met by SMS-to-911 which might happen if RTT-to-911 were referred to as “text-to-911”. SMS has been great advance – and for those who use SMS daily – it will be how they ‘call’ 911. But SMS is not as effective as RTT in an emergency conversation, and it does not allow captioned telephony which can be life-saving for older adults and others that will call 911 using voice but cannot hear what 911 says back reliably.

With respect to RTT support for legacy PSAPs, the RTT to TTY gateways can provide this compatibility as explained in previous paragraphs.

We feel that the dropping of VoIP due to power outages, and the loss of RTT along with this is not a disability access issue. If power outages cause VoIP to fail, then everyone at that location will be at risk irrespective of disability and preferred mode of communication. We believe that as long as RTT is handled as a standard component of VoIP, people who rely on text or voice+text to communicate will be able to communicate as long as voice users of VoIP are able to. We also believe that as we move from PSTN to VoIP that there will be continuing efforts to make VoIP networks more and more

reliable against the loss of power for all users. The reliability of RTT should be exactly the same as the reliability of the voice channel.

Redundancy is always an important means to achieve reliability and availability. So, as long as analog calls to 911 are supported TTY access should be supported. Where VoIP calls will be connected to the PSTN in order to reach 9-1-1, then conversion of RTT to TTY should be supported.

It has been suggested that that wireless devices be required to provide both IP and circuit switched access, with a unified internal user interface for RTT as well as circuit-switched wireless TTY. However, the efforts to change the wireless TTY implementations from external TTY attachment to internal may be seen as too big to be achievable within the proposed deadlines for RTT deployment.

> 70. *Based on comments in the record, we propose that compliant RTT must be capable of transmitting text instantly, so that each text character appears on the receiving device at roughly the same time it is created on the sending device. To achieve this, we further propose requiring that RTT characters be transmitted within one second of when they are generated, with no more than 0.2 percent character error rate, which equates to approximately a one percent word error rate. We believe that this will allow text to appear character-by-character on the recipient's display while the sender is typing it, with a point-to-point transmission latency that is no greater than that provided for voice communication. We seek comment on these proposals, as well as whether the Commission should adopt other measures regarding the latency and error rate for RTT. For example, is it feasible, and necessary for effective communication, to provide users with the ability to edit individual characters or groups of words in real-time – for example, by backspacing and retyping?*

We recommend the latency be no more than 300 msec.

The proposed performance requirements above do not meet the goal of providing end-to-end latency that is no greater than the latency for voice communication.

From a usability perspective, latency is to be measured as a maximum end-to-end latency. It is however hard for a device manufacturer to guarantee network performance. Therefore, end-to-end latency needs to be broken into the device and network components. On the device side, the latency requirement is expressed as the maximum time that text is stored (buffered) before transmission. The network latency time is added on top of the buffering time by the device. If, for example, the network latency is less than a maximum of 200 milliseconds (common for modern IP networks), and the device latency is 800 milliseconds, the end-to-end latency is a maximum of 1000 milliseconds.

For the purposes of determining what the maximum device latencies can be without compromising usability, it is important to distinguish between the use case of using RTT for non-voice-synchronous typing, and using RTT for captioned telephone services (network or on the phone) where voice and the text transcription of it flow in parallel. The performance requirements for these two are distinct:

Real-time text used for non-voice-synchronous typing. The proposed rule implies that end-to-end latency is a maximum of 1200 milliseconds (200 milliseconds from the network, and 1000 milliseconds from the device). Usability research has shown that in a typed text conversation, end-to-end latency of one second between typing a character and its display on the receiving side is experienced as acceptable, while at two seconds latency, the users start feeling annoyance and collide in turn-taking[5] Thus, the NPRM would result in higher latencies than what ITU-T recommends, although it is possible that

[5] See ITU-T F.700 and ITU-T F.703

1200 ms as opposed to the ITU-T-recommended 1000 ms will not significantly compromise usability. Either latency, however, is higher than the recommended maximum end-to-end latency for voice conversations, which is only 400 ms[6].

The proposed safe-harbor standard RFC 4103, recommends a sampling of text for 300 milliseconds before transmission, resulting in an end-to-end latency of 500 milliseconds. Alternatives to RFC4103 commonly consume more bandwidth, required passing through servers and require feedback, so they may need to be sent with longer intervals than the safe harbor standard and thereby cause the longer latencies. But with RFC4103 which does not require such bandwidth or servers, 300 ms is recommended.

Real-time text for captioned telephony (text synchronized with voice). As mentioned in the previous paragraph, for speech conversations, the acceptable end-to-end latency is much lower than 1 second: only 400 ms, and at higher latencies, users start experiencing user annoyance and problems with turn-taking. Consumers have indicated that lag between speech and captions is their number one complaint about IP-CTS; in a survey done by Gallaudet University this was picked as the top problem with 60% of respondents selecting it as an issue[7]. It follows that it is highly probable that a maximum of 400 ms end-to-end latency for captions via real-time text that is similar to the latency for voice, would provide the best possible captioned telephone service usability. In fact, the delays for producing captions at the relay service provider, before transmission, are

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[6] See ITU-T G.114

[7] Linda Kozma-Spytek, Paula Tucker, and Christian Vogler. Presentation of survey results given to FCC on April 24, 2013. Online: http://tap.gallaudet.edu/CTSSurvey/results.asp (Last Accessed: 7/11/2016)

often so high that any addition of a second delay via buffering transmissions can cause the user to have trouble seeing the relationship between the spoken words as heard on the phone and the captions.

For these reasons, for the captioned telephony use case, a shorter latency between text entry and its transmission is highly desirable. If the ITU-T-recommendation for 400 milliseconds or less for voice telephony are taken as the maximum, together with a maximum network latency of 200 milliseconds, the latency on the device side should not exceed 200 milliseconds. Note that this requires shortening the recommended default RFC4103 transmission interval from 300 milliseconds to 200 milliseconds, and sending five packets per second. Note further that the 300 millisecond transmission interval specified in RFC 4103 is a recommendation, and the standard allows for other values to be specified for specific applications.

In conclusion, for the proposed latency requirement:

- The device buffer latency should be a maximum of 800 milliseconds if 1000 milliseconds end-to-end latency is the goal for typed text.
- 1000 milliseconds device latency, resulting in 1200 milliseconds end-to-end latency for typed text, is likely acceptable.
- If a captioned telephone conversation is initiated (by the device via voice recognition or the network), for best usability, the device buffer latency should not exceed 200 milliseconds. Typed real-time text conversations can still employ higher latencies, as per the above, to minimize the demands on the network.

Regarding the questions about editing text, there is a need to be able to delete and modify recently entered text. This is mainly for correcting mistakes, and it would be frustrating for users if this ability were not present. Since transmissions are done in real-time, erasing text and other corrections also need to act in real-time on already transmitted text displayed by the remote terminal device. RFC 4103-based RTT has no concept of specific message identifier. In current applications, the line separator (Unicode code point U+000A) works as a message delimiter. Erasing text must be able to move past such line separators, and into earlier text.

71. *We also note that, according to the Technology Research Centers, any RTT system also can be programmed to first receive and hold the sender's communication while it is being composed, and to then send the entire message together when triggered to do so, in a manner akin to instant messaging. Is this "block mode" feature desirable for certain individuals? For example, would it alert people who are deaf-blind to incoming messages so that they know when it is appropriate to respond? If so, should we allow or require that this capability be made available on compliant RTT technology? If such a feature is permitted or required, should we require nevertheless that RTT service revert to the character-by-character mode when 911 calls are detected by the IP network, in order to ensure the rapid exchange of information during such calls?*

There are a number of times when this is desirable or essential for user. For example – someone trying to correct text by copying it, pasting it into the input field and editing it before sending it. Others may have tremors or other problems that require that they be able to clean text up before sending to keep the resulting text stream for jumping back and forth due to edits. This feature should be allowed. If implemented, it should be regarded to belong to the user interface to RTT and not to the RTT transmission standard. It should also be turned off during emergency calls. The best solution would be a mode where 911 operators can see what is in the buffer as the caller edits – but the "pre-edit" buffer still works so that the RTT client behaves as users expect the feature to work, and they do not get further stressed if they notice that they cannot do their "pre-edit" as

planned, because that might confuse or disturb successful use of text during the emergency call.

This feature should not activate any specific signaling to deafblind users. Instead it would be beneficial to be able to configure that the reception of a Line Separator causes a brief tactile or visual or audible signal. This can be useful for anybody.

Note: We suggest that this capability be called “EditHold” rather than ‘block mode” to prevent confusion with other block mode communication technologies.

72. *We seek comment on any other relevant considerations pertaining to the transmission and delivery of RTT that may affect its utility and effectiveness for people with communication disabilities.*

We have included these in other sections of the document.

73. *We propose to require that, for a manufacturer’s or service provider’s implementation of RTT to be considered compliant with the rules the Commission adopts in this proceeding, users of RTT must be able to send and receive both text and voice simultaneously in both directions over IP on the same call and via a single device. We seek comment on this proposal.*

There are users for whom the opportunity to mix spoken and written communication is essential. For example, both local and remote captioning of phone calls as well as people who text annotate key parts of their communication for a user. There are also users who have no interest in voice communication; for example someone who is deaf and also does not speak. There are at least two reasons to include the proposed requirement for all RTT communication:

- Audio should be provided from the site of an emergency call as guidance to the PSAP operators in their assessment of the emergency.
- It is not wise to fragment the market of this product in special types that are of value only for a small part of the users.

- Note: For deaf users, any activation of the audio channel should be obvious to them since they cannot hear what the background audio is around them (e.g. in their house) and turning on audio when they do not know it is turned on is similar to turning on the video without user awareness on an audio call.

Note also that the RTT should allow voice and text simultaneously and in both directions (for a total of 4 channels of communication) in order to allow interruption and requests for clarification on a call without destruction of the communication.

74. *According to the 3GPP Technical Specification for Global Text Telephony, which is cited by the DAC, RTT that is implemented under RFC 4103 allows text to be transported alone or in combination with other media, such as voice and video, in the same call session. The DAC therefore asks the Commission to consider "whether telecommunication and advanced communications systems can support the use of RTT simultaneously in conjunction with the other Real-Time media supported by the system." The DAC also recommends that the Commission consider whether RTT equipment and services should support, among other features, the user's ability to "intermix voice and text on the same call, including, for example, 'Voice Carry Over' [VCO] and 'Hearing Carry Over' [HCO]." Such "carry over" modes currently are available as types of TRS. VCO allows people who are deaf and hard of hearing to use their own voices (where possible) and receive text back during a captioned telephone or TTY-based relay call, while HCO generally allows people with speech disabilities on speech-to-speech relay calls to hear directly what the other party says and use the CA to repeat what the person with the speech disability says. However, in an RTT network, can these features also serve as a mode of direct point-to-point communications, reducing the need for reliance on TRS?*

The natural mode of operation for RTT is to enable use of RTT at the same time as any other real-time media. It may for example be audio or video. No alternating shall be needed. The users just transmits in any mode and receives in any mode, and use the modes simultaneously or in sequence as they like. No specific operation shall be needed to switch between modes. All are available at the same time. A simple and easily available operation may be needed when a medium is to be used for the first time in a call. Because of the nature of IP and SIP, this is the default behavior of the technologies unless something is done to limit them.

This smooth operation enables convenient handling of e.g. using text one way and voice in the other way in point-to-point calls. It also enables talking as long as it works but occasionally ask for a word or two to be typed. The ease of using such communication forms and the general availability of them in wireless settings will reduce the need of relay services in some situations.

The VCO and HCO concepts get reduced to be keywords for the manual of operation for relay services. Technically, RTT simply allows "simultaneous media". Requesting HCO will indicate that a relay service shall only operate by reading out RTT text. VCO will indicate that a relay service shall only operate by typing in RTT what they hear in the voice path.

The usage of the VCO and HCO terms for point-to-point calls would better be replaced with some easier understood terms for what is expected by the participants in the call. This will get more important the more widespread use these modes of operation get. A hard-of-hearing user could say: "Please type, I talk" as a key to getting into the VCO-like usage of the media in the call. A person with speech disabilities would type "Please talk, I will type" as a key to getting into the HCO-like usage of the media in the call.

Note that for this way of using RTT to have any effect on the equality in communication and to the usage level of TRS, it must be very simple to start using RTT in a call. And this should be true of communication devices in operation, regardless if they are in use by persons with disabilities or not. It should be sufficient that only one participant in the call requests RTT to be included in the call for RTT to be activated. For users who rely on RTT, the request to activate RTT in the call should be automatic. For

those who need RTT occasionally, RTT should be included in a call by a very easily available control in the user interface. Devices provided to the general public should be prepared at delivery so that they at least automatically accept to include RTT in calls where it is requested by the other party in the call. The need that often appears in everyday voice calls to spell something exactly, that is so cumbersome by voice spelling make it however desirable for all to have an easily available operation for hassle-free inclusion or RTT in any call.

If users depend on text or voice+text in calls, they want to be sure that they get the text support they need in the call before calling or answering. Point-to-point calls with mixed voice and RTT will therefore first become popular between family members and other situations where it is apparent by the context that the hearing party has the right type of device and accepts to handle RTT in the way that is needed for the call.

In order to achieve more widespread use for this approach, in order to reduce load on the relay services, it would be required that a mechanism for rapid inclusion of a relay service in the call is established for cases when the hearing party is not capable of taking part with RTT in the call, because of technical or human reasons.

75. *Consumer Groups point out that simultaneous voice and text on the same call also would allow callers to initiate a call using either text or voice and to switch to the other mode at any time during the call. Users would be able to send text in one direction and speech in the other, speak in parallel with text for captioned telephony, and supplement speech for difficult-to-hear words, addresses, and numbers. Trace et al. report findings that the quality, intelligibility, speed, and flow of communications improve when text is added to voice. Finally, the Technology Research Centers point out that the ability to use synchronized voice and text transmissions can improve communications on TRS calls. We seek comment on these assertions and the extent to which synchronized voice and text transmission is necessary for effective communication via RTT.*

There are many situations where these opportunities are valuable for achieving equivalence in communication. For users who want to have both voice and RTT,

synchronization between them is relevant. If speech is provided first, and then, within a short time period, the corresponding text is presented (for example captioned telephony or speech+voice recognition or speech plus typed words for difficult words), then a listener/reader who can get benefit of the combined presentation for understanding the communication. Text is of value also if provided after longer delays, but not with the same level of usability. See also comment on point 70 about latency. See also comments under point 73.

> 76. *Next, we seek comment whether to require that, where covered service providers support the transmission of other media, such as video and data, simultaneously with voice, they also provide the capability for the simultaneous transmission of RTT and such other media. We note that in studies conducted by the Technology Research Centers, participants generally expressed the desire to add video to RTT calls, "to express feelings, and to provide for more natural communication with sign language and the possibility of lip reading." In addition, some commenters highlight the benefits that multimedia capabilities can have in the TRS context, including the ability to supplement sign language communications with text on video relay calls. By enabling voice, text, and video to be delivered to users so that each of these types of media can be available at the same time, over the same call session, some parties also state that RTT can reduce overall reliance on TRS and also reduce or eliminate the need for TRS users to acquire the dedicated terminal equipment that is often needed to access these services. They claim that increasingly, people with and without disabilities would be able to converse with each other directly, using whichever mode of communication – voice, text, or video – is most suitable for getting their messages across.*

The combination of audio, video and RTT is called total conversation, and defined in ITU-T Recommendation F.703. And it is true that many users of RTT ask for video to be included in the service. Because of its richer media contents, total conversation has even higher ability to satisfy communication without relay services than the plain RTT with audio. However, many situations will still require availability of relay services. So, efforts should be spent to enable VRS and TRS calls with wireless total conversation terminals rather than expect the users to never use the relay services. The ability to make calls without VRS and call it in only when needed however could result in consumers starting without it first, rather than just always including it to be sure, and lead to reduced demand for relay services.

77. *To what extent is requiring such multimedia capabilities necessary to achieve telephone communications for text users that are as effective as those available to voice users? To what extent can such capabilities enhance the accuracy and speed of TRS or reduce overall reliance on conventionally defined forms of TRS, to ensure that TRS is available "in the most efficient manner"? Would the inclusion of video capability with RTT be likely to lead to congestion problems, and how could such congestion be prevented or alleviated? For example, if simultaneous voice, RTT, and video are all available over the same telephone connection, could the parties to the call better simulate an in-person communication, which can be supplemented with RTT as needed, and thereby eliminate the need for a CA to serve as a communications bridge between the parties?*

This is a hard question to answer well. As discussed above in comments to point 76, it is likely that general availability of total conversation will reduce but not eliminate the need for relay services. Some voice phone users will only be prepared to talk, and most sign language users think it is more rapid and convenient to use sign language than RTT. Direct point-to-point calls with total conversation will therefore not satisfy all cases and therefore cannot be called "equivalent" to voice telephony. The ability to communicate in sign language – but use RTT for numbers, addresses and other exact information – can greatly speed communication and reduce error.

The video requirements for good sign language communication can be satisfied with less than 400 kBit/s per call. This is more than audio and RTT calls, but far less than video conferencing and IPTV. The development is going toward having video in user-to-user calls, so having video in these calls because of accessibility reasons will contribute very little compared to the increase in bandwidth usage due to other reasons. Therefore the risk is low that there will be congestion in the overall network because of video in total conversation calls. A bigger risk is that people without disabilities decide to use video in a regular call – but that is outside the scope of this discussion.

78. *We generally seek comment on how to integrate RTT into the provision of TRS. Specifically, should the Commission amend its TRS rules to authorize or require TRS providers to incorporate RTT capabilities into platforms and terminal equipment used for certain forms of TRS, in order to enhance its functional equivalence? For example, Omnitor asks the Commission to require relay providers to incorporate RTT into their systems, so that callers can use RTT terminals to access*

TRS with a single step, using ten digit numbers. We note that at present, some forms of TRS are provided over the PSTN, while others are made available via IP networks. In light of the ongoing migration of communications from the circuit-switched PSTN to IP-based technologies, it appears that ultimately all PSTN-based TRS will be phased out and all TRS will be IP-based. If this occurs, should we authorize or require IP Relay or other TRS providers to support an RTT mode between the user and the CA? If so, what timeline would be appropriate for implementing such capability? The Technology Research Centers suggests this is needed to improve the functional equivalence of the IP Relay interface, as well as to facilitate relay service modes, such as VCO and HCO. Should we also authorize or require IP Captioned Telephone Service (IP CTS) or other TRS providers to support RTT transmission in any voice channels they provide and in any off-the-shelf equipment provided to IP CTS users? Finally, should we authorize or require VRS providers to support an RTT mode between the user and the CA, so that RTT can be used to supplement communications in sign language with text during VRS calls? What other requirements are appropriate to assign to RTT or TRS providers to ensure the compatibility of their services as the transition to RTT takes place?

For interconnected VoIP, to meet the requirement of supporting RTT wherever voice is supported, the logical consequence is that 711-based state TRS services will need to support RTT during relay calls. Otherwise, there would be – from the user perspective – a completely artificial schism between dialing phone numbers for direct RTT+voice calls, and using a different non-phone number based method to contact relay services. This kind of schism would not be in line with the principle of functional equivalence.

79. *Commenters in this proceeding point out that one advantage of RTT is that it allows communications using the full Unicode character set, as compared with the more limited character set available on TTY transmissions. They point out that besides facilitating communication in languages other than English, this capability allows users to transmit emoticons, graphic symbols that represent ideas or concepts – independent of any particular language – and specific words or phrases that have become integral to text communications in our society. In addition, commenters report that RTT can be equipped with the ability for users to control text settings such as font size and color, to adjust text conversation windows, and to set up text presentation.*

We agree with this assessment.

80. *We seek comment on the technical feasibility, costs, and benefits of requiring that these features of RTT be supported by a covered service provider's implementation of RTT. How can each of these capabilities meet the needs of people with specific disabilities? For example, can the availability of emoji characters help people with cognitive disabilities better communicate with and receive information from others? How well do special characters and emoji's translate into voice, and what are the challenges of and best practices for enabling this capability? Is it necessary or desirable to have characters based on Unicode for them to be accessible to screen readers used by people who are blind, visually impaired or deaf-blind? Similarly, to what extent can the ability to set text style and text presentation layout contribute to usability, readability and comprehension of RTT? Should there be an option for the user, depending on preferences and needs, to configure the display of incoming and outgoing text in a certain way? Finally, we seek comment on the extent to which these capabilities are affected by the properties of network transmissions.*

Control of font sizes and color are essential to meet the accessibility requirements of people who are blind or visually impaired, as well as older adults with declining vision. Without these capabilities, they would be prevented from using RTT in the first place. As RTT interfaces can be implemented to look similar to other text-based communication interfaces, and other text-based communication interfaces offer control over fonts and colors, there is no inherent technical limitation that would prevent RTT interfaces from implementing such controls. We do not see how the properties of network transmissions impact the design of such controls and the user interface more generally.

81. *We believe that RTT is appropriately classified as an "electronic messaging service" and that as such, both RTT services and the equipment used with them are subject to the requirements of section 716 of the Act and part 14 of the Commission's rules. Therefore, we believe that, independently of any rules specific to RTT that are adopted in this proceeding, RTT services and end user equipment used with them must be accessible, usable, and compatible with assistive technologies, as defined by part 14, to the same extent as is currently required for telecommunications and advanced communications services and equipment under the Commission's accessibility regulations. We seek comment on this position.*

We agree with this assessment.

82. *We also seek comment on whether it is possible to identify, more specifically than is currently identified by our part 14 rules, certain RTT features or functional capabilities that are needed to meet the communication needs of individuals who are deaf-blind, people with cognitive disabilities, or other specific segments of the disability community. For example, should we require compatibility with certain assistive technologies used by people who are deaf-blind, such as refreshable Braille displays or screen enlargers? In addition to providing emoji's, are there other measures that can be taken or required to make RTT effective for people with cognitive disabilities? For example, should there be a mechanism for slowing up the receipt of text, or an option to enable message turn-taking to make it easier for these individuals to receive and read incoming messages? What features should be incorporated on terminal equipment used by these individuals to allow easy activation and operation of RTT functions?*

Slowing down text display is also required for refreshable Braille displays, as the reading speed for Braille tends to be far lower than the speeds at which many people type. Moreover, receiving text while someone is typing on a Braille keyboard could also cause confusion, and it may be better to hold incoming text back until the user has finished typing and is ready to read incoming text on the Braille display. More generally,

deafblind users must be involved in the design of suitable accessible and usable RTT interfaces from the beginning.

> 83. *In addition to the above specific capabilities, the DAC recommends that the Commission consider whether compliant RTT equipment and services should be required to support the following telecommunications functions that are available to voice-based telephone users:*
>
> *The ability to "transfer a communication session using the same procedures used in voice telecommunication endpoints on the system";*
>
> *The ability to "initiate a multi-party teleconference using the same procedures used in voice telecommunication endpoints on the system";*
>
> *The ability to "use messaging, automated attendant, and interactive voice response systems"; and*
>
> *The ability to use caller identification and similar telecommunication functions.*
>
> *We tentatively conclude that such functions should be available to RTT users as necessary for effective communication, and we seek comment on this tentative conclusion, including the costs, benefits, and technical feasibility of supporting these functions. We also seek comment on the extent to which the availability of each of these functions may be affected by how a service provider implements RTT in an IP network.*

These supplementary services belong to the set of such services that are usually made available to voice users and should be made available to RTT users as well.

> 84. *Additionally, we seek comment on whether to require that compliant RTT provide the ability to participate on multiple calls simultaneously and to leave and access voice and text mail, both of which are also telecommunications functions that must be made accessible to people with disabilities by federal agencies under section 508 of the Rehabilitation Act. Trace et al. explain that when retrieving messages from voice mail, text information, including the name of the caller, return number (from caller ID), length of the call, time of the call, and related details could be sent and be viewable on screens. For IVR prompts, they report, instant text of all the choices could be made available to callers.*

These are desirable and feasible services. As RFC 4103 is transmitted via RTP, just as voice is, there is no inherent technical reason why a feature should be available for voice, but not for text.

D. Support of RTT Functionalities in Wireless Devices

> 85. *We propose to require that handsets and other end user devices subject to an RTT support requirement be required to support each of the RTT functionalities discussed above for service*

providers. We seek comment on this proposal, including its costs, benefits, and technical feasibility. To what extent are these features and functions under the service provider's or manufacturer's control? Are there other features and functionalities that should be required for end user devices to effectively support RTT? Further, to what extent can such features and functionalities and their associated benefits be obtained if RTT is not fully incorporated as a native function of end user devices, but is merely available for users to download or install as an over-the-top application? To what extent would it make a difference if an RTT application is installed as a "default" app prior to sale of a handset or end user device?

We agree that terminals should support the additional and supplementary services described above in point 83. More specifically:

- **Call Transfer.** This is a useful function needed for full functional equivalence. When using RFC 4103, it is implementable in a design very similar to the same function without RTT, because RTT is handled as any other RTP based medium. Both the terminal and the service provider need to support this function.
- **Initiate and take part in multi-party conference call.** The most commonly used conference support uses a multi-party bridge in the network to coordinate and mix the media. This type should be supported by service providers. When using RFC 4103 for RTT, the function is easily implemented as for any other type of call, but with the RTP-carried RTT being mixed in a way that maintains readability of each RTT stream. Such implementations exist – they switch among users typing at the same time upon encountering a line break, or upon receiving no activity for a set amount of time. This is a function that the terminal can be unaware of, in the same way that voice phones are not aware of conference bridges.
- **Messaging, automatic attendant and interactive voice response system access:** Automatic attendant and interactive voice response system access via

RTT should be supported. The voice response systems are best supported by offering navigation by RTT (e.g., transmitting "1," "2," etc. as RTT) , while traditional control by DTMF may also be provided. Both types are feasible when based on RFC4103. The terminal needs to be able to transmit numbers as both DTMF and RTT; the rest of the functionality is implemented by the provider of the voice response system.

86. *In order to ensure that individuals can use a single device on multiple networks, to the same extent as is currently possible with voice communications, there must be a stable interface between user equipment and VoIP networks. For example, if subscribers to one wireless provider were to lose RTT communication capability when they insert a subscriber identity module (SIM) card for another wireless provider into their smartphones, then the inter-network portability achieved for voice users' smartphones would be unavailable to RTT users, and our rules may fail to achieve functional equivalence in this critical respect. Therefore, we propose to require, at a minimum, that covered service providers enable device portability for their RTT services to the same extent as they enable device portability for voice services. We seek comment on this proposal.*

We agree that the proposed requirement is feasible and important. It can only be valid within service provider groups using the same technology in the same way as migrating devices for voice calls across networks – that is, GSM to GSM, and CDMA to CDMA.

87. *We also seek comment on the extent to which all necessary functionalities for effective use of RTT can be made available through provider-approved devices and applications, or whether third party software applications will be needed for some RTT features and functions. To what extent will consumers need access to third party RTT software applications on user devices to supplement native RTT capabilities that are integrated into such devices, in order to achieve functional equivalence with voice communications? Should the Commission require providers to offer an "app interface" to facilitate access to third party applications?*

While the native RTT functionality should be made accessible to the greatest number of people possible out of the box, we recognize that there may be specific user groups for whom more specialized applications can met their needs, such individuals with multiple disabilities (e.g deafblind users, and users with reduced hearing and cognitive abilities). We recognize that there may be network security concerns associated with providing a full API to the phone's native voice and RTT functionality. However, if the native RTT

functionality is skinnable – that is, app developers can customize the appearance, text display and input functions –, this may be sufficient to meet the specialized needs of these groups.

88. *In the event that the Commission adopts requirements for device portability or the enabling of third party applications, or both, we seek comment on the availability or feasibility of a safe-harbor standard for a user-network interface that could support the RTT capabilities of user devices and applications from multiple manufacturers and providers. Alternatively, are there reasonable performance criteria that could be applied to ensure that a network-user interface can support multiple third party devices and applications?*

'We do not know what is meant by a "user-network" interface, but we are concerned if this means that regular phones and other VoIP devices would not be accessible themselves and that instead some other interface for other devices would be provided. This would put us back into the same situation we had with TTYs where people needing text or text+voice would be using special devices and could only call other people who had special devices unless they used the relay system..

89. *Last, we seek comment on equipment costs to consumers that may result from the transition from TTY to RTT technology. In response to the Emerging Wireline Notice, various parties noted the importance of taking into consideration the affordability of such devices as IP-based technologies take the place of legacy communications systems. For example, AARP pointed out that "not all TTY users may currently have the necessary mobile devices, and the broadband data plans, necessary to make them operate." Additionally, some individuals may have severe or multiple disabilities that will necessitate assistive technologies along with mainstream RTT-capable devices to connect to an IP network. AARP cautioned that the Commission should proceed carefully so as not to "leave some users behind, or place them in a position where the technology alternative is prohibitively expensive." Similarly, the Michigan Public Service Commission noted the importance of ensuring that a customer's current assistive equipment is compatible with the substitute service, and suggests that "if the consumer must purchase new equipment . . . to accommodate the new service, the issue of who will be responsible for the cost needs to be addressed." Other parties responding to the Emerging Wireline Notice, however, opposed inclusion of affordability as a criterion for determining the adequacy of a replacement service in the transition to IP networks. AT&T stated that there is "no evidence that wireless and IP replacement are generally less affordable than the TDM service they replace." In addition, AT&T and others pointed to the availability of support under Universal Service programs to qualifying customers.*

We agree that the cost for VoIP+RTT solutions should be less than the cost for their PSTN counterparts and provide more functionality. As VoIP replaces PSTN, the cost for telecom-only IP connection (or limited IP connections for basic communication) should

not cost more than the PSTN connection today. It is true that a real internet connection could cost more than a PSTN connection but that is a different topic and related to data use.

We believe that a concerted effort by the FCC to encourage the creation of a low cost, ultra-simple telecom device (voice, text and video) (perhaps a contest) would result in solutions that are both very simple and much less expensive than today's TTYs.

> 90. *We seek comment on whether there are measures the Commission could take in the context of this proceeding to ensure the affordability of new terminal equipment or assistive devices that may be needed as a consequence of the migration to RTT technology, and whether such measures are appropriate. We expect that many off-the-shelf VoIP devices will be usable with RTT – eliminating altogether the need for specialized equipment. In addition, we note that several states have programs that distribute specialized communications equipment to people, often based on their economic need. Similarly, the Commission administers the National Deaf-Blind Equipment Distribution Program, which provides funding for certified state programs to distribute communications equipment and provide related services to low income individuals who are deaf-blind across the United States. AARP recommends that carriers seeking to transition to IP systems be required to work with governmental agencies that distribute such assistive equipment to qualified individuals with disabilities. We seek comment on the appropriateness of this suggestion, and other ways that the Commission can alleviate any burdens that might be associated with acquiring new equipment or software, particularly for those who do not qualify for existing state and federal equipment distribution programs or for those will need to replace devices not covered by such programs.*

We agree that RTT-capable devices should be included in the distribution channels of equipment distributors. in particular, a low cost device such as described in 89 might be a good candidate, and could be designed to work for people who are deafblind and have other multiple disabilities as well.

VII. Consumer Outreach and Notifications

> 91. *To ensure a seamless TTY-RTT transition, we seek comment on the best means of informing the public, including businesses, governmental agencies, and individuals with disabilities who will be directly affected by the transition, about the migration from TTY technology to RTT and the mechanics of how this technology will work. To be effective, RTT must be usable by people with and without disabilities. Accordingly, we tentatively conclude that such outreach should not only focus on people with disabilities, but also on the general public that will be communicating with such individuals, and seek comment on this tentative conclusion. We seek comment on whether the statutory authority on which the Commission proposes to rely for the purpose of regulating the provision of RTT is sufficient to authorize outreach requirements with respect to RTT. We note*

that the Commission has previously used its authority under section 225 to require service providers to conduct outreach about TRS, and we ask whether we can rely upon such authority to require outreach on RTT. What are the most effective methods to provide such notification, and to what extent should covered entities coordinate with consumer and industry stakeholders to develop effective messaging and outreach initiatives? Further, to what extent should the outreach conducted by manufacturers and service providers include outreach to the operators of public TTYs and Wi-Fi phone installations?

92. *We propose that the conditions imposed in the Bureaus' waiver orders remain in effect, until the full implementation of rules adopted in this proceeding. These conditions include a requirement for waiver recipients to apprise their customers, through effective and accessible channels of communication, that (1) until TTY is sunset, TTY technology will not be supported for calls to 911 services over IP-based wireless services, and (2) there are alternative PSTN-based and IP-based accessibility solutions for people with communication disabilities to reach 911 services. These notices must be developed in coordination with PSAPs and national consumer organizations, and include a listing of text-based alternatives to 911, including, but not limited to, TTY capability over the PSTN, various forms of PSTN-based and IP-based TRS, and text-to-911 (where available). We tentatively conclude that the provision of this information is necessary to ensure that, during the transition period, there is no expectation on the part of consumers with disabilities that TTY technology will be supported by IP-based wireless services, and to ensure that these consumers know that alternative accessible telecommunications options exist, and seek comment on this belief. We further propose that all information and notifications about the RTT transition be provided in accessible formats, such as large print, Braille, and other appropriate means to make information accessible to people with disabilities. We seek comment on this proposal. Are any different or additional notices needed to ensure that consumers are aware of potential issues regarding 911 communications during a TTY-RTT transition?*

We agree with keeping the requirements in place. As to new information, there will undoubtedly be additional information needed by consumer to avoid confusion and to allow them to take advantage of the new capabilities being made available to them.

93. *Finally, we tentatively conclude that, consistent with the usability requirements of our rules implementing sections 255 and 716 as well as previous actions by the Commission to educate consumers about TRS, covered entities should be required to implement a mechanism to provide information and assistance during business hours to their consumers regarding the TTY-RTT transition, and seek comment on this tentative conclusion. We seek comment on how this can best be achieved. For example, to what extent should covered entities be required to designate staff trained to assist consumers with the complex issues related to the TTY-RTT transition? Are there additional mechanisms for outreach education and assistance that should be adopted?*

VIII. Other matters

94. *Security Concerns. We seek comment on security risks that may be associated with the adoption of RTT technology and that require the Commission's attention. The Technology Research Centers point out the availability of technical methods to secure SIP calls, both for call control security and media security. They also caution against "blocking of RTT," which they say could occur where security or IT management personnel are not aware the need to support of real-time text. They explain that this can be remedied by the use of a "SIP-aware firewall," which will allow the proper pass-through of RTT once deployed. We seek comment on these and other security concerns that should be addressed through this proceeding, including the costs, benefits and technical feasibility of implementing specific security measures.*

IX. RTT IMPLEMENTATION IN IP-BASED WIRELINE NETWORKS AND EQUIPMENT

95. *We seek comment on whether, in addition to requiring the implementation of RTT by wireless service providers, we should amend our rules to require the implementation of RTT in IP-based wireline networks. As discussed above, problems associated with TTY transmissions are not limited to those that occur over IP wireless networks. Because TTYs were not designed for the IP environment, they have not performed well in any IP-based system; in fact, many of the problems associated with TTY use over IP-enabled wireless networks – e.g., dropped packets and data connection stability issues – also occur in wireline networks. Thus, as an initial matter, we seek comment on the extent to which wireline IP networks can reliably support TTY communications.*

Yes, the same provisions should apply to wireline because all the same issues with respect to TTY transmission arise there (although bandwidth is not as precious as on wireless). Also, with the advent of Fixed Wireless many consumers will not know (and there will be vanishing distinction between) the difference between wireline and wireless connections to houses. Whether something is wireline or wireless is likely to be determined mostly by which is less expensive for companies to deploy.

Unless the same rules are applied to both wireline and wireless, adding a leg of one technology or another could change the rules of the game – and changing the last leg in service may result in different customers of the same service living under different rules. Similarly, the same customer could have the rules change simply if the provider changes how the IP connection to the customer's house is set up.

96. *Moreover, there is considerable information in the record that in any communications environment, TTYs remain inadequate with respect to their speed, their limited character set, and their failure to allow the simultaneous communication enjoyed by voice communications users. We thus next seek comment on whether we should amend our rules at Parts 6, 7, 14, and 64, to allow or require wireline VoIP service providers to support RTT, as we are proposing to do for wireless services. What would be the costs, benefits and technical feasibility of such requirements? We believe that for RTT to effectively replace TTYs, and allow full integration by people with disabilities into our nation's mainstream communications system, the ability to access our nation's wireline VoIP services using RTT will be just as important as the ability to access wireless services, especially if TTY technology is phased out. Many, if not most businesses, government agencies, and retail establishments continue to rely on wireline services, and having telephone access to such enterprises will be necessary for people with disabilities who rely on text to maintain their independence, privacy, and productivity.*

See comments to point 95. Regarding the cost, the solutions on IP wireless and IP wireline are very similar so there are not many barriers to wireline adoption of wireless strategies. In fact, wireline should be easier to implement and less expensive than wireless for both providers and consumers.

97. *If we do amend our rules governing wireline services to incorporate RTT support obligations, how can the Commission ensure that end users can readily connect to and use such RTT capabilities in wireline IP networks? For example, given that wireline Part 68 customer premise equipment such as wired and cordless phones currently cannot readily support real-time text, would it be feasible and practical for wireline VoIP service providers to offer over-the-top RTT applications downloadable to text-capable devices such as smartphones, tablets, and computers, that could then be used to connect to the carrier's VoIP service platform? Should wireline VoIP providers be required to ensure the compatibility of their services with third-party RTT applications present in stand-alone devices or downloaded onto text-capable devices such as smartphones, tablets, and computers? To what extent should wireline VoIP manufacturers have RTT support obligations for their equipment that is otherwise capable of sending, receiving and displaying text? To the extent that IP-based wireline service providers and manufacturers have an obligation under our rules to support RTT, should they be required to adhere to the same interoperability requirements, minimum functionalities, and outreach obligations that we propose to require for wireless VoIP services and end user devices? Finally, is RFC 4103 an appropriate standard to reference as the safe harbor for wireline VoIP services and text-capable end user equipment to ensure interoperability and compliance with the rules proposed for wireless services?*

Technically, there should be no barriers to creating applications that can run on various IP devices to provide RTT+voice to any VoIP carrier. However, we are not familiar enough with the security provisions needed by carriers to keep others from abusing their networks if the have an open API. This may be easy or difficult and warrants further exploration. However, the techniques and code to add these capabilities into their current wireline offerings are available. Again this should be reserved for special interfaces for multiple disabilities and their default applications should made accessible to the the majority of people with disabilities who need RTT or RTT+Voice to communicate.

RFC4103 should be named as a safe harbor for wireline for the same reasons as for wireless. Note also that for some systems it may become impossible to determine if they

are wireline or wireless, as hybrids evolve, and thus both need to support the same standards.

98. *We also seek comment on the appropriate timing for incorporation of RTT capabilities into wireline VoIP services and end user devices, in the event that rules requiring such capabilities are adopted, and the extent to which such timing should be determined by the manufacture or sell date of new devices. Similarly, should requirements for RTT support also be triggered at "natural opportunities"? We also seek comment on whether RTT would be particularly beneficial in the context of Inmate Calling Services (ICS), particularly given the problems ICS users have encountered in trying to use TTYs, and whether there are specific issues the Commission would need to consider in relation to the use of RTT by inmates.*

The same deadlines and rules as for wireless should be applied to wireline – for the same reasons as for wireless, also because the two systems have always been designed to work seamlessly together. A consumer should not have to know if the other person will be answering on a wireless or wireline or fixed wireless connected phone to know whether their RTT or RTT+voice call will go through.

99. *Finally, how should TTY support obligations be modified as wireline networks discontinue their circuit-switched services? Should wireline providers that support RTT on their IP networks be permitted to cease supporting TTY technology at all, and if so, on what timetable? In comments filed in response to the Emerging Wireline Order and Further Notice, AARP has raised concerns about establishing firm dates for the sunset of TTY technology, given that a large number of carriers "serving millions of subscribers, may continue to deliver voice services over legacy facilities for an extended period. AARP claims that "[a]dopting hard and fast sunset dates may lead to customer confusion, and place undue burdens on some service providers and their customers" and urges that, if the Commission establishes a termination date for TTY technology, it do so only for specific carriers that have filed for section 214 relief. We seek comment on these claims and how we should consider the needs of consumers who still use TTYs in framing rules to address a transition to wireline implementation of RTT.*

See comments above on wireless. As long as there is a PSTN we cannot sunset TTY support. However, providers that implement VoIP and RTT should not have to support TTYs except where they connect their VoIP network to a PSTN network. There they would have to meet the same gateway conversation provisions as wireless providers. As the PSTN disappears, so would their responsibility to support TTYs. The PSTN can be made to disappear sooner by providing alternate IP connections to people.

3. Comments on Topics Not Raised in the NPRM

In this section we comment on topics that were not raised in the NPRM and that do not fit with any of the other questions. These pertain to maximizing the usability of RTT and ensuring that no one gets left behind in the TTY transition.

Visual indicators of sound: TTY users today can see via a status light that visually displays the audio activity on the line, allowing users to see sounds on the line. They can recognize ring and busy tones, whether someone has answered and is talking, etc. Although for RTT, ring and busy tones can be indicated through status messages during the session setup as part of SIP, displaying a visual indicator of the audio is still important. This indicator – for example, a visual sound bar displaying the volume of the received audio in real time, or a simple spot of light that flickers with audio activity – is needed to tell people who cannot hear the audio whether a voice answering machine has connected, someone is speaking on the line, or whether there is any kind (or not kind) of audio activity.

Simple devices on fixed wireless lines: If fixed wireless lines are slated to replace landline PSTN, there needs to be a migration path for users who rely on simple devices on landline PSTN for access – such as standalone TTYs and analog captioned telephones (see also point 90). Currently, no equally simple IP-enabled RTT devices are available as drop-in replacements for these. In the case of TTYs, an equally easy-to-use standalone RTT device must be made available to users. In the case of analog captioned telephones, standalone IP CTS devices could in principle serve as drop-in replacements on fixed

wireless lines, but in order for this to happen, both the IP CTS devices and the service providers must offer RFC 4103 as a supported protocol for captioning.

We believe that a simple voice+RTT+video device that could serve as a TTY replacement using RFC 4103 could be created that is both simpler to operate and significantly less expensive to manufacture and distribute than TTYs.

Similarly, a simple IP phone with display could be distributed that would serve as a low cost universal IP-CTS device using RFC 4103 that could be soruced from multiple vendors and simple to operate.

Note that in principle for TTYs, a transcoding gateway from TTY to RTT could be provided to the end user, but such an approach would be potentially more expensive and less robust than migrating to an equally simple TTY replacement, for the reliability and robustness reasons discussed in points 62-63. A similar approach for analog captioned telephones is not likely to be feasible altogether, because none of the available devices support any kind of industry standard for transmitting captions, which greatly increases the difficulties associated with developing and providing a gateway to the end user for such phones.

Respectfully submitted,

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